METALLURGIA

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The Future Trend in Forged and Cast Light Alloys

By W. C. Devereux.

Quality is the keynote of future development in the application of forged and cast light alloys, and those who have concentrated on this important factor can look forward to a steady demand and widening fields.

THE past year has been one of intense growth in the use of the high-quality aluminium alloys that obtain their maximum physical properties by heat-treatment, many applications being found both in the wrought and cast shapes. Applications have been new and numerous in industries which are not usually associated with the desire of saving weight, and yet the many instances where aluminium alloys have been successfully applied, such as in textile machinery, printing and carding machines, box-making machines, packing machines, chocolate and sweetmeats and tobacco machinery, the rubber industry, and even in wire-fencing machines, cause me to say that in the desire in all these industries to speed-up by saving the unnecessary moving of weight, the lowering of inertia loads, or just a saving of effort in plain manual work, one can look forward to improved business.

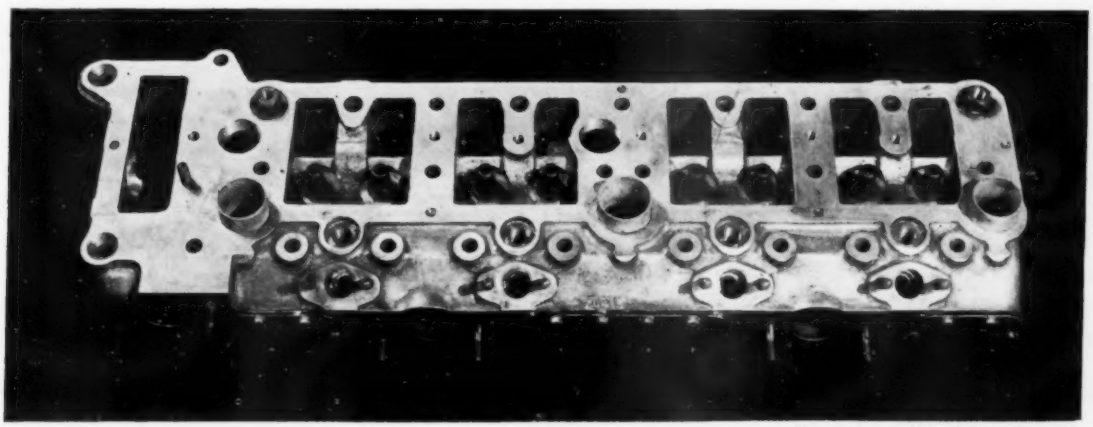
The aluminium alloy industry generally has been through a trying time, due to the lack of demand which has forced prices down to an uneconomic level. This very fact has caused the elimination of the cut-throat business, the heads of which have not always been imbued with the desire of quality; the consequence is that the far-seeing firms who, despite the keen competition, have been willing to stipply only the quality article—particularly where new applications are at stake, even if temporarily at the risk of certain loss of immediate business—are now able to look forward to a steady demand, wherein quality is much more sought after than it was twelve to eighteen months ago.

The principal demand for aluminium alloys, of course, still comes from transport, included in which is the aeronautical field. The advent of the Diesel engine to commercial vehicles and rail coaches has made a noticeable increase in the demand, which is likely to still greatly enlarge. The principal applications are for cylinder heads, connecting rods, and pistons, whilst applications are found for gears, both of the timing gear and back axle worm-wheel type.

Further, the high quality cars are calling more and more for the use of aluminium alloys, not only in the form of castings for cylinder blocks, heads, crank cases, and other castings, but also as forged connecting rods, and for many applications, such as in the form of forgings and stampings for frames and the body work.

Forged aluminium alloy connecting rods, of which many thousands a week are made, are certainly coming back to favour, due to the greater knowledge of the technique of manufacture and the introduction of alloys more suitable for the purpose. The obvious use of light alloys for connecting rods is for the sweeter running of engines, and results, like the aluminium alloy cylinder head, in economy. Apart from this, the lighter rod is found to have a definite influence on the life of the bearing, both of the rod and crankshaft, and in this connection I feel sure one may look with a good deal of confidence to the introduction of good aluminium alloy bearings in a not far-distant future.

Never before has aluminium alloy research been so prolific of promise for the future. The advent of the heat-treated cast alloys must, however, be looked upon with a good deal of insight and understanding. Those alloys relying on high-temperature treatment for their maximum properties can only as yet be safely regarded as suitable for castings of simple form, and where the design does not permit of any locked-up stress, otherwise it will be found that although test-pieces cut from such castings will give



By courtesy of High Duty Alloys Ltd.

A Diesel engine cylinder head casting in Hiduminium RR 50 alloy, heat-treated.

By courtesy of High Duty Alloys Ltd.

Diesel engine connecting rod which runs direct on case-hardened shaft.

high test figures only a portion of this strength is available for service.

The greater understanding of the use of X-ray for crystallographic research and strain investigation will have a good influence on the industry in the preparing of new alloys or in the improving of existing ones.

Of one thing I am certain, that the aluminium alloy industry of this country is equal in knowledge and production methods to any nation abroad, and I feel that in correct applications of alloys we probably lead the world. No nation in the world has been able to produce ingot of aluminium alloys to equal that produced here, and in spite of the price competition export business has been good. To what extent the devaluation of the dollar will affect our export business remains to be seen. We must rely on safeguard measures by our Government.

Forged alloys will be used in increasing quantities now that the knowledge of forging is so well understood, and one can see the replacement of steel forgings in many instances with advantage in both efficiency and in ultimate economy.

Magnesium alloys will continue to have useful applications, principally in the transport industry, but I am of the opinion they will find a somewhat limited application principally for parts which are not stressed or complicated in design, and that the application of forged and stamped structures of magnesium will not show the advance made by the cast material, but there will be an increasing use made of sheet and extruded section. On the other hand, the increasing knowledge by the designer of the better methods of applying aluminium alloys to castings must revert in many instances to the use of aluminium alloys, particularly in those applications where even moderately elevated temperatures are encountered. In connection with magnesium alloys, I know that research on heat-treatment has resulted in improved test figures on test-pieces, but I am of the opinion that the same restriction applies to this type of treatment as to high temperature heat-treatment of aluminium alloys—one can only see an immediate application for simple structure.

There is an increasing demand in the shipbuilding industry for aluminium alloys in the form of forgings or wrought-bar and tubes. The demand is for an easily worked alloy, particularly in cold work. There is also a steady demand for sheet. As regards sheets, here the demand must necessarily be for corrosion resistance alloys, which is being filled by the use of alloys of various proprietary brands, the principal element added to the aluminium to give corrosive resistance properties being magnesium from 3 to 10%.

Much is being done, and much remains to be done in regard to surface treatment of aluminium alloys, in order to provide a protection against corrosion, and also to provide a coat suitable for and capable of obtaining a firm adherence of paint and dope. Here the future is bright, and one is not nearly so diffident of offering the ultimate solutions for the various problems.

I will finish, as I began, on a note of optimism, and say that the future as far as the aluminium alloy industry is concerned is prolific of promise of much improvement.

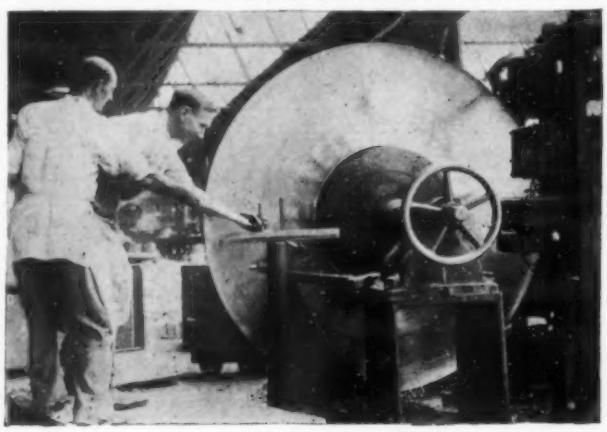
Developments and Applications of Aluminium and Its Alloys

ALUMINIUM and its alloys are being increasingly applied in practically every branch of industry, and it may be said that no other metal or alloy has made so much progress in recent years. Even during what has been claimed as the worst depression the world has ever known, there has been a gradual increase in the consumption of aluminium. Although of comparatively recent application consumption is estimated to exceed 300,000 tons per year, and some idea of the progress in the post-war years is grasped from the fact that consumption never exceeded 70,000 tons before the war. Much of this progress is due to intensive research in the development of alloys possessing physical properties that render them eminently suited to a wide range of applications : improved technique in manufacture of suitable alloys have made standardisation possible, with the result that there is greater confidence in the use of aluminium alloys where their characteristic low relative weight is an advantage. Not only are many alloys now available which, with suitable treatment, have physical properties comparable with steel, but many have been developed with unique corrosion-resisting properties.

It is not possible to indicate the relative proportion of consumption of aluminium and its alloys in the various branches of industry, but it can be assumed that the transport industries have been quick to realise the economic advantages of their weight/strength ratio. Thus, for instance, motor engineering and body building accounts for a large proportion, while aluminium alloys are being increasingly used in motor and railway coaches. The rapid development of aerial transport has only been possible as a result of the development of light alloys included in the field of aluminium alloys.

Spinning a large aero tyre tube or mandrel.

By courtesy of The London Aluminium Co. Ltd



During recent years much progress has been made in the application of aluminium alloys for equipment and components in dairies, and dairy churns are now frequently made in aluminium. It may come as a surprise to the layman to learn that aluminium is beginning to replace tinplate for the milk cans of 8 or 10-gal. size which are distributed throughout the country, yet this is one of the more recent applications. Not only has the relatively short life of the tinned article led to the introduction of aluminium, but recent experiments tend to prove its superiority to the latter metal from the hygienic standpoint, and many of the important dairies are carrying out investigations with a view to making greater use of aluminium. Those interested in the applications of aluminium in the dairy industry should see the exhibits in the engineering section of the British Industries Fair at Castle Bromwich.

Aluminium is also being applied to the making of beer barrels. Here again the hygienic and other advantages of this material has led to its replacing the old-fashioned and inferior type of cheap container. What is most important, however, is that the aluminium barrel for lager, being made like a boiler to withstand internal pressure, is employed for the actual sterilisation of the beer at upwards of 60 lb. per sq. in. pressure. For this purpose the aluminium barrel is manufactured with swaged-on belts of steel or duralumin, so that the mechanical strength is far and away beyond anything required in service. In actual tests these barrels have been filled and dropped from a considerable height on a concrete floor, or rolled into steel stanchions without any injury. It is interesting to note that the aluminium container actually keeps its contents cooler when exposed to strong sunlight, inasmuch as the reflecting power of the bright metal is greater than its absorbing capacity.

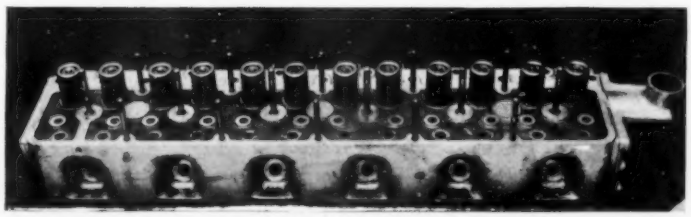
Various kinds of bottles are being turned out in seamless aluminium, not only for beer and milk, where the application is somewhat experimental, but for essences, essential oils, perfumes, and chemicals. Here again aluminium is being adopted, not because it is cheaper than its substitute, but because it is better. Many of these seamless aluminium bottles are lined with a chemical-resisting lacquer, which is baked on and which renders the container immune from any corrosion by its contents. Such chemicals as formaldehyde and acetic acid are regularly packed in aluminium drums.

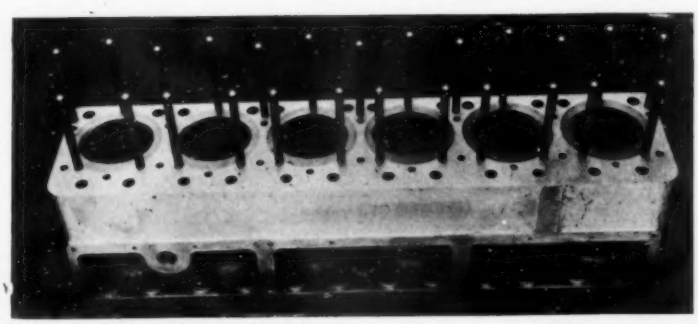
The rayon industry leans very heavily toward the use of aluminium in its equipment, since aluminium has so far proved very satisfactory in resisting the attack of acid and alkaline solution used. Large tanks and other plant components in aluminium are now conspicuous in the plant

By courtesy of The London Aluminium Co. Ltd.
Completing an aluminium aero tyre mandrel.

and machinery used in this industry. Among the smaller pieces of equipment, an interesting example is the perforated bobbins on which the viscose silk is wound for washing purposes. These bobbins have to be made with the utmost precision and exactitude. Here again, in many instances, a special form of baked lacquer is employed for treatment in order to give a longer life to the metal component when in contact with acid solutions.

Many hundreds of thousands of aluminium trays have replaced wood in the food and confectionery industry. The reason is not cheap first cost, but hygiene. Not only bacteria, but the lava of the chocolate moth have been found to breed in a prolific manner in the crevices of the wood trays previously used, and the perfect cleanliness obtainable by clean metal, allied with its strength and light weight, has brought aluminium to the fore. Refrigerator ice trays, too, though of a different class, are being stamped in a variety of sizes and shapes, and furnished with partitions dividing them into compartments. The moist conditions of service require a rustless material, and one which will not corrode or form unpleasant coatings. In this connection it is interesting to note that anodic oxidisation is employed. The grey oxide film, artificially produced on aluminium, is now well known. It has been found one of the best methods of resisting the effect of the atmosphere either on land or sea, and it provides the metal with a coating which, while it cannot be chipped, is actually harder than the metal itself. Numerous colours for decorative purposes have been developed by the use of this





By courtesy of High Duty Alloys Ltd.

Top left.—Automobile cylinder head.
Bottom left.—Automobile cylinder block.
Both in Hiduminium RR 50, heat-treated.

Below.—Air-cooled aero engine cylinder head Hiduminium RR 53, heat-treated.

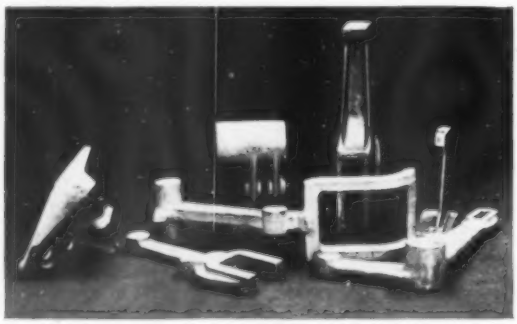
film, and these colours, in an opaque or semi-transparent form, are making headway in architectural details and fittings.

One of the industries in which aluminium is a useful servant is that concerned with rubber. Two facts are of importance here. First, that the sulphur used in vulcanising has simply no effect on aluminium. Secondly, rubber

Typical castings in a recently developed aluminium alloy R.R. 53B.

articles formed on aluminium are very readily peeled off without sticking. As a consequence, the light metal is ideal for formers and tyre mandrels. Some of the latter have recently been made in gigantic sizes for the landing wheels of the giant air liners now in operation. The production of these mandrels has for some time been a specialised development of the London Aluminium Co. on what are, perhaps, the largest spinning lathes in use in England. Still larger sizes are produced by building up and welding.

Among the wider uses being made of aluminium may be mentioned outdoor signs consisting of coloured designs and lettering on a background of the metal. A period of experiment has shown that with proper treatment and pigments, virtually everlasting signs can be made, using aluminium as the basis, and the advantage rests not only in the attractive appearance and absolute freedom from rust, but also in flexibility. The vitrified and enamelled signs on sale have perhaps every advantage but this—they are easily chipped by stones or other missiles, and are absolutely inflexible. The aluminium sign can be bent around a pole, lamp post, or any portion of a vehicle body where it is used for advertising purposes, without a sign of cracking. In fact, many signs have been deliberately dented and afterwards flattened out with ease, so that no sign of damage remained.



Some machinery parts in Hiduminium R.R. 53B.

The remarkable fact about the development of aluminium and its alloys is not so much the amount of valuable research and experimental work that has been successfully carried out, but the rapid manner in which it has been assimilated by many industries and the results applied to meet new and existing conditions of service. This is particularly applicable to the high-duty alloys that have been developed, such as Duralumin "Y" alloy, and the more recent "Hiduminium" R.R. alloys, all of which are obtainable in the extruded, forged, and stamped conditions, or as sheets, tubes, etc. The use of these alloys as forgings and stampings have increased during the last few years beyond the wildest dreams of those responsible for their development, and their application in the future is very encouraging; only by extreme care in the manufacture and in the applications, however, will development really succeed.

Special claims are made from new alloys from time to time. Frequently, however, these are developments of existing alloys that have been in use for some years. Perhaps the principal developments of recent years have been the production of harder alloys, among which should be mentioned the still relatively new RR 53, which is used as a casting alloy, and RR 56, a forging alloy. With suitable heat-treatment, RR 53 will show a Brinell hardness of 130–140. A slight modification of the standard RR 53 alloy has been developed recently, known as Hiduminium RR 53 B, which is proving of great use for such parts as fast-moving levers, treadles, and brackets in the textile and electrical industries, and for the smaller form of castings for the aircraft industry. This alloy has the following analysis:—

Copper.	Nickel.	Magnesium.	Iron.	Silicon.	Aluminium.
% 2·5 ..	% 1·5 ..	% 0·8 ..	% 1·2 ..	% 1·2 ..	Remainder

The physical properties of this alloy in various conditions are as follows:—

CHILL CAST.

	0·1% P.S. Tons Sq. In.	Max. Stress, Tons Sq. In.	Elong. %.	Brinell Hardness.
As cast	8	12	1½	80
Solution treated	12	17	3½	110
Solution treated and artificially aged	19	21	1	129

The specific gravity is similar to RR 53 alloy.

The alloy introduced is the result of many months of research work in the laboratory of High Duty Alloys, Ltd., with the object of altering the standard Hiduminium alloys to suit a particular purpose, and is, of course, one of the series of alloys introduced and patented by Messrs. Rolls Royce.

A number of alloys have now been developed which have very high corrosion-resisting qualities. Of these mention may be made of the range of aluminium alloys developed by Cindal Metals, Ltd. Another alloy which has valuable corrosion-resisting properties is M.G. 7; particularly is this alloy resistant to the corrosion of saline atmospheres and waters. In addition, however, it possesses the strength of fully heat-treated and aged Duralumin.

There are two types of corrosion to which the strong light alloys of aluminium are prone. Firstly, and principally, surface corrosion, accompanied by pitting; secondly, intercrystalline corrosion. The first type is visible, and though it is a distressing and troublesome phenomenon, it may be observed and checked. The second type, intercrystalline corrosion, however, penetrates from the surface and beneath the surface of the material, and advances into the material along the crystal boundaries, so that a marked fall in ductility and a slighter fall in strength may occur with relatively little indication of corrosion on the surface of the material.

While the aluminium is pitted by the action of the sea-water, and covered with a film of corrosion deposits, this alloy remains unpitted and of bright surface. It is protected by patent rights. Composed mainly of aluminium, its other constituents are magnesium and manganese, and actually it is lighter than aluminium, having a specific gravity of 2·63. It will be seen from the accompanying table that its properties are such as make this alloy of conspicuous and outstanding interest and value.

TABLE I.

PROPERTIES OF MG7.

	1% Proof Stress.	Max. Stress. Tons per Sq. In.	Elong. %.
Annealed	11·0	.. 22·0 ..	20·0
Rolled or drawn ..	19·0	.. 25·0 ..	12·0
Hard rolled	25·0	.. 29·0 ..	6·0
Brinell hardness Nos.....	90—115		
Fatigue range	9·5 — + 10·5 tons per sq. in.		
Izod impact value	17 ft. lb.		

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British Iron and Steel Industry.

THERE can be no doubt that the departure from the Free Trade policy formerly in operation in this country has been a decided advantage to many industries primarily concerned with home trade. The duty on imported iron and steel, for instance, has helped manufacturers of heavy steel very considerably by diverting orders hitherto placed on the Continent to British mills, but there is little indication of recovery in the export trade. It is true that conflicting political troubles abroad tend to impede the reciprocal and co-operative efforts by which trade recovery must succeed; it must be realised, however, that we are passing through a very difficult phase in which readjustment is essential to economic recovery. For this reason it is important that definite schemes of industrial reorganisation should be put into operation without undue delay; representatives of each section must determine how industry can best be shaped to meet new conditions and new opportunities. The iron and steel industry is experiencing a period of transition, and a scheme of adjustment is under discussion, but, apparently, disagreements over details tend to undermine the principles on which the scheme is based.

Much has been said that is not particularly helpful in solving the difficult problems associated with the operation of the scheme contemplated for this industry, and in order to present the true facts we asked Mr. Charles Mitchell, chairman of Dorman, Long and Co., Ltd., and chairman of the National Committee for the Iron and Steel Industry for an expression of his views on the effect of Protection on our export trade and the steps taken to reorganise the industry. His reply, as follows, is enlightening but it indicates that unanimity is not yet reached.

Various statements have appeared in the Press during the past few months regarding what is commonly referred to as "The Reorganisation of the Iron and Steel Industry," and many have been misleading and erroneous.

The iron and steel industry for the past decade has been in a depressed condition, the result of happenings which are so well known that I need not repeat them.

Leaders of the industry have approached successive Governments with a plea for Protection to combat the menace of the dumping of foreign steel, which they submitted was essential if this vital industry was to survive. Eventually they succeeded, and the present National Government granted Protection, in the first place in a somewhat halting manner—*i.e.*, for a limited period. This was subsequently extended for two years, and the Government, through the Tariff Advisory Board, stipulated that in return for this protective duty, the iron and steel industry must—to quote the words of Sir George May "put its house in order and supply the right material at the right price." The National Committee of the Iron and Steel Industry was set up in June, 1932. Various meetings and prolonged discussions have taken place during the last eighteen months, with the result (I quote from a speech I delivered to a recent dinner of the London Iron and Steel Exchange):—

"It is now possible to set up machinery which will, I trust, in the course of time, function as the hub of the wheel of the iron and steel industry of this country and in due course of the Empire. The machinery will be there and it lies with the iron and steel trade itelf to make it a strong and effective organisation, co-ordinsing the various sections of the industry within itself and by itself, presenting a united front to foreign competition, and enabling it to compete successfully in the available markets of the world."

There is considerable divergence of opinion with regard to the merits and demerits of Governmetntal intervention or control. I do not believe—and I think a large majority of the trade are of my opinion—that Governmental control is necessary or would be benefital to the industry.

Co-operation with the Government is essential, but it should be left to the trade itself to work out its own salvation and re-establish itself on a sound basis, so that the Government could have every confidence if the country should at any time be in danger. In addition, the investor could expect a reasonable return on the money he had put into the industry.

Last year was the first complete year in which the policy of Protection had the opportunity of demonstrating its effects. A considerable tonnage of foreign steel is still being imported, but during the year 1933 it has been reduced by approximately 2,000,000 tons. The output of pig iron in the United Kingdom for 1933 was 4,120,000 tons and of crude steel 7,000,000 tons, as against 3,570,000 tons and 5,260,000 tons respectively in 1932. During the closing months of the year the steel industry was operating at approximately 70 per cent. of estimated productive capacity, a higher rate than in any other country in the world, where reliable and comprehensive figures are available.

With regard to the export market, it can, I think, be said that Protection has given us a means of bargaining we did not previously possess, and will, in due course, enable us to compete more favourably in the markets of the world. Unfortunately, the uncertainty created by the currency difficulties in foreign countries has hampered our export trade, and until these difficulties are overcome it is not easy to estimate the benefit derived from the tariff.

Generally speaking, conditions are much more encouraging, and a spirit of hope and confidence within the industry has been created, and iron and steel makers are fully alive to the difficulties of the present situation.

The investigations and discussions that have taken place during the last eighteen months have demonstrated the necessity for closer co-operation in the industry whose earnest desire and aim is to restore the iron and steel trade to its premier position in the industrial life of the nation.

Since this communication was received from Mr. Mitchell an indication of the urgency of the acceptance of some reorganisation plan is shown by the publication of a letter sent by the Import Duties Advisory Committee to each member of the National Federation of Iron and Steel Manufacturers. The period during which the additional duties on iron and steel products have been extended is due to expire on October 25 next and in the absence of a fresh recommendation from the Committee, those duties would come to an end. The Government have yet to be convinced that a strong and effective organisation will be set up to co-ordinate the various sections of the industry to warrant the continuance of the protective duty. Probably some definite decision will result from the meeting of the representatives of the iron and steel trades on February 22, certainly no time should be lost in putting a scheme into operation.

BRITAIN'S VAST SHOP WINDOW.

THE British Industries Fair is different from the majority of other industrial exhibitions in that it is entirely concerned with British potentialities in the industrial field. The extent of the field covered and the comprehensive character of the exhibits renders such an exhibition, devoted entirely to products of the British Empire, almost essential, because it provides a huge shop window that brings potential buyers not only from all corners of the Empire but from all parts of the world. It gives manufacturers the opportunity of showing to what extent progress is being made in the application of science and art to the service of mankind and of illustrating the part being played by British enterprise. It is difficult to show definite progress in the comparatively short time of a year since the last Fair, but the observant visitor will note the progressive tendency in the year's effort; particularly will it be noted that quality is of primary importance, a feature which has always been fostered by the spirit of emulation which promotes a desire for a superior product.

The Fair is divided into three main parts: At the White City, for instance, textiles, furnishing fabrics, and furniture are shown; at Olympia the products of the lighter industries are displayed; while that at Castle Bromwich shows the work of the heavier industries. The floor area of the buildings occupied in London and Castle Bromwich exceeds 30 acres, while the frontage of indoor stands exceeds 32 miles. It is interesting to note that 2,545 exhibitors are participating; at Castle Bromwich, the exhibits with which we are primarily concerned, there are 1,002 exhibitors, and for convenience their exhibits are divided into six main groups—gas, electricity, building, engineering, hardware, and heating. The whole Fair is bigger than ever, and with the ever-increasing demand for space the time must inevitably come when additional sections will be necessary; when that time comes no doubt the claims of the North to house part of the Exhibition, particularly that associated with the heavy industries, will be appreciated.

A very encouraging sign about the present Exhibition is the attention which it has attracted abroad. Twenty-two countries are sending their trade buyers and the services of interpreters in nine foreign languages are available to assist visitors in making a survey of the products exhibited. The great advantage of the facilities afforded by this Fair is the fact that it brings into personal contact manufacturers and potential buyers, and even though direct orders will undoubtedly result, it promotes possibilities for future buying that are not always appreciated by exhibitors.

With the signs of trade recovery which have been apparent for some months, we believe this Fair will give a further impetus and assist materially towards a restoration of normal activity, and incidentally show that the progress in manufacture and production in the British Empire is very real—a fact which is responsible, in no small degree, for the maintenance of British industries in the forefront of world progress.

The Institute of Metals.

Annual General Meeting.

The Twenty-sixth Annual General Meeting of the above Institute will be held in the Hall of the Institution of Mechanical Engineers on March 7 and 8. In addition to the business meeting, there will be three technical sessions the programme of which is as follows:—

March 7 (a.m.).—"Minimum Dimensions of Test Samples for Brinell and Diamond Pyramid Hardness Test," by G. A. Hankins, D.Sc., and C. E. Aldous, B.Sc. "Note on the Influence of Gases in an 8% Copper-Aluminium Alloy on Mornal and Inverse Segregation," by I. G. Slater, M.Sc., Ph.D. "Diffusion of Zinc and Iron at Temperatures below the Melting Point of Zinc," by G. Rigg.

March 7 (p.m.). "Influence of the Intercrystalline Boundary on Fatigue Characteristics," by H. J. Gough, D.Sc., H. L. Cox, B.A., and D. G. Sopwith, B.Sc.Mech. "The Viscous Properties of Extruded Eutectic Alloys of Lead-Tin and Bismuth-Tin," by C. E. Pearson, M.Met. "A Note on Some Formulæ concerning Viscous and Plastic Flow in Soft Metals," by E. W. Fell, Dr. Ing.M.Sc. "Castability of Ternary Alloys," by Professor A. Portevin and P. Bastien, Dr.-es-Sci.

March 8 (a.m.). "Alloys of Silver and Beryllium," by H. A. Sloman, M.A. "Transverse Tests on Sand Cast Aluminium Bars," by C. E. Phillips and J. D. Grogan, B.A. "The Constitution of Copper-Iron-Silicon Alloys," by Professor D. Hanson, D.Sc., and E. G. West, Ph.D. "Transformations in the Copper-Palladium Alloys," by R. Taylor, B.A., B.Sc.

Forthcoming Meetings

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Mar. 2. "Immersion of Propellers," by Dr. Ing. G. Kempf.
Mar. 16. "Experiments upon Models of Coasters—Effect of Stern Variations," by F. H. Todd, B.Sc., Ph.D.

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Mar. 1. "Field Tests on Corrosion," by J. C. Hudson, D.Sc.

LONDON SECTION.

Mar. 15. "Spectroscopic and Microchemical Analysis of Metals and Alloys," by G. Barr, B.A., D.Sc., and Miss Hadfield, M.Sc.

NORTH-EAST COAST SECTION.

Mar. 13. Annual General Meeting.
Address by J. E. Newson, M.Met.

SCOTTISH SECTION.

Mar. 12. Annual General Meeting.

SHEFFIELD SECTION.

Mar. 9 "Nickel-chrome Plating," by Frank Mason.

SWANSEA SECTION.

Mar. 13. Discussion on Rolling to be opened by Professor L. Taverner, A.R.S.M.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

Mar. 2. "The Hardening of Cast Iron," by H. Beeny, M.Met.

EAST MIDLANDS BRANCH.

Feb. 24. Lecture by H. E. Beardshaw (at Derby).
Mar. 10. Annual Dinner (at Loughborough).

LANCASHIRE BRANCH.

Mar. 3. "Some Aspects of Non-ferrous Founding," by A. Logan.

BURNLEY SECTION.

Mar. 6. Annual General Meeting.
"The Annealing of Castings," by J. Jackson.

PRESTON SECTION.

Mar. 7. "Metal Treatment by the Oxy-Acetylene Process," by H. P. Smith.

LONDON BRANCH.

Mar. 7. "Potentialities of Cast Iron," by A. B. Everest, Ph.D., B.Sc.

MIDDLESBROUGH BRANCH.

Mar. 9. "Steel Castings with Special Reference to the Tropenas Process," by John E. Mercer and D. K. Barklay.

NEWCASTLE-ON-TYNE BRANCH.

Feb. 24. "The Work of the Institute's Technical Committee," by A. Logan.

SCOTTISH BRANCH.

Mar. 1. Discussion on Report of Steel Castings Research Committee.
Mar. 10. "Coke Research," by Wm. Davidson.

FALKIRK SECTION.

Mar. 3. "Problems I have Met," by W. McArthur.

EDINBURGH SECTION.

Feb 24. "The Foundry Cupola," by R. S. M. Jeffrey, B.Sc.

SHEFFIELD BRANCH.

Mar. 16. "The Use of Sodium Carbonate in Iron and Steel Works," by N. L. Evans.

WEST RIDING BRANCH.

Mar. 10. "Porosity," by E. Longden.

MANCHESTER METALLURGICAL SOCIETY.

Feb. 28. "Materials Questions in Steel Tube Manufacture," by J. W. Jenkin, Ph.D., B.Sc.
Mar. 14. "The Platinum Metals," by A. R. Raper, M.A.

Scientific Research and the Non-ferrous Metal Industries

The onward march of science is becoming increasingly important to the non-ferrous metal industries, says Mr. Colin G. Fink, of Columbia University, and not even the worst depression experienced in the economic life of the world has been able to check this forward march. Some of his views on the subject are abridged in the following article :—*

THE last fifteen years furnishes an example of progress in the non-ferrous industries unparalleled in human history. The tremendous outburst of energy brought forth by the world war, the ingenuity called upon to meet the many emergencies arising from lack of essential materials, the high degree of organisation, and the general supply of funds made available, far outweighed the waste and destruction of materials occasioned by the cataclysm, and hurled technique and science ahead at greatly accelerated speed as soon as all energies could again be turned to peaceful pursuits.

In the production and utilisation of non-ferrous metals advance in scientific achievement is being accompanied by some striking developments. Low-cost metals are being substituted for those generally used for certain purposes, largely as the result of the addition of small amounts of alloying constituents that materially enhance the original properties of these metals. Improved methods of production, providing lower extraction costs, are giving impetus to this trend. New uses for many metals, particularly for the more uncommon ones, are being rapidly developed. The outlook for any non-ferrous metal may therefore be said to include, under the rapid advance of scientific research, the prospect of marked change in utilisation or production.

By the application of new methods the recovery of aluminium on a commercial scale from ores other than bauxite may be expected within a comparatively short time. Research to this end is progressing in an encouraging manner in several countries, particularly in Norway, where a combination process is understood to have been evolved that utilises iron ore and clay to produce an alumina-containing slag, from which aluminium is subsequently recovered. As soon as such processes are perfected, the price of aluminium will decrease, and utilisation of the metal will undoubtedly expand sharply, probably at the expense of other metals.

The electric furnace is a most valuable tool which the older generation never possessed. With this new, high-temperature apparatus available reactions can be brought about which our forefathers assumed would take place only in the sun. Whereas the engineer in the past has largely directed his efforts in breaking down complexes to simpler products, thus starting out with complex coal-tar or complex sulphide minerals and getting the final relatively simple components, the tendency of the new era is to start out with two or more relatively simple elements of compounds, and, with the aid of electrical energy, bring about combinations resulting in products demanding new uses and new applications. For 30 years efforts have been made to produce pure tantalum metal. A few experiments were made in the development of making tantalum alloys. Only recently, however, have we realised that possibly the biggest application of tantalum will be in tantalum compounds rather than in the pure metallic product. Thus, tantalum carbide has found wide application in the cutting industry.

Another illustration is the history of the mining and metallurgy of titanium. For a good many years efforts have been concentrated in developing the best and cheapest methods of recovering titanium metal from its minerals, ilmenite and rutile. To-day the industry is concerned largely with titanium compounds. Thus, titanium pigment manufacturers have been operating at practically full capacity during the recent awful years of the depression, and the imports of ilmenite ore were the highest on record, from the standpoint of both tonnage and value. Titanium pigments have become serious competitors of lead pigments. Investigations now under way promise to broaden the titanium compound field even far beyond that now covered by the paint industry.

In the non-ferrous industry the trend is towards the development of markets for so-called impurities previously buried in the refuse. A typical illustration is tellurium of the copper industry. The output of tellurium during the four years of the depression has been about fourfold that of the prosperity years 1929 and those immediately preceding. This increase is due largely to the discovery that small additions of tellurium to the zinc electrolyte facilitate the elimination of the very objectionable cobalt impurity. Tellurium plates a quarter of an inch thick and more have been electro-deposited. What use may we find for tellurium-plated metals ?

The electrolytic copper industry is disposing of all of its selenium, largely to the glass industry ; selenium forming the basis of the red glass of traffic signals. Not many years ago the only commercial application of selenium was for the selenium photo-cell.

Between 60 and 70% of the copper consumed is absorbed by the electrical industry. Can we assure that copper will always be the basic metal of this industry ? There are too many instances in the past where new discoveries have completely changed the "essential" basic materials. Thus, for instance, in the communication field, in many cases it has meant the complete elimination of the telegraph wire. With wider use of better-conducting metals, such as sodium, copper may cease to be the basic metal of the electrical industries.

As in the copper industry, so likewise in the zinc industry. The by-product metals have become a very prominent item in the total output of zinc plants. Cadmium, one of the main by-products, is now looked upon as "a regular member" of the family of non-ferrous metals, but there are indium, germanium, and gallium, anxiously awaiting a market and use. Experiments have been made on the electro-deposition of indium, with promising results, notably on silver. Germanium appears to be available in quantities much larger than we had ever anticipated. Gallium emits electrons at lower temperatures than other metals and offers valuable applications in this field. Apart from the utilisation of the three metals, gallium, germaniun, and indium, as such, the biggest promise of the future appears to lie in compounds of these three metals, previously looked upon as outsiders.

The composition of the earth's crust has been studied, and we know that aluminium and magnesium are by far more abundant than most of the other metals. A very significant demonstration of the valuable physical properties of magnesium and its alloys was given recently, when the gondola of the Settle stratosphere balloon was built of magnesium alloy, and withstood the very high pressures to which it was exposed. It is difficult to look upon a metal such as magnesium as being in a class with a metal like steel on the basis of physical and mechanical properties. We assume that an alloy of magnesium cannot be produced which will have mechanical properties anywhere near those of the usual steels, but some magnesium alloys have proved a big surprise to our ferrous metallurgists.

In conclusion, Mr. Fink feels justified in predicting that the mineral industries are going to invade fields from which they have, in the past, been almost entirely excluded. It is necessary to get away from the belief that compounds which are naturally found in the crust of the earth are the only ones possible. With the facilities now available we can, at very high temperatures, or under the influence of very powerful electric discharges, or through the action of very powerful chemical and physical means, bring about reactions which even nature has not produced in the past.

* *Engineering and Mining Journal*, January, 1934, pp. 31–33.

Balanced Heat in Iron and Steel Works

By W. J. Brooke.

Obtaining all heat requirements is simple in theory; in practice, however, conditions vary. In this article these variations are discussed and the advantages of scientific control of gases and waste heat described.

FOR many years the ideal of obtaining all the heat requirements on a combined iron and steel works from the utilisation of the coal at coke ovens has been the aim and aspiration of many steel works operators. Theoretically, the idea is perfectly simple; the coal is turned into coke, surplus oven gas together with the leaner gas from the blast-furnaces is then employed for the manufacture, heating, and rolling of the ingot, in addition to the generating of electric power and other ancillary services that may be required. In practice it is not quite so simple, as conditions vary so much in different districts, and again with the variety of coal and ores used at the ovens and blast-furnaces. This may be illustrated by two examples, which roughly express the extremes of what one may meet as regards the conditions referred to.

South Wales.—Coking coal in this area in general contains a somewhat low percentage of volatiles, in the region of 21–25%. The ores used are in great measure fairly rich in iron and imported from abroad on account of the proximity of the seaboard. In the making of a ton of iron usually less than 20 cwt. of coke are used, and 1 ton of coke calls for 26·3 cwt. coal, and which yields about 12,900 cub. ft. rich gas of, say, 510 B.th.u. value.

One ton of coke yields approximately 150,000 cub. ft. lean gas of, say, 98 B.th.u. value. The total heat value of gases per ton of Welsh pig iron would therefore be as follows:—Say, 19 cwt. coke per ton of iron = 25 cwt. coal = 12,250 cub. ft. rich gas at 510 B.th.u. = 6·25 million B.th.u. gross.

$$19 \text{ cwt. coke} = \frac{150{,}000 \times 19}{20} = 142{,}500 \text{ at } 98 \text{ B.th.u.}$$

$$= 13{\cdot}96 \text{ million B.th.u.}$$

Total = 20·21 B.th.u. gross per ton Welsh pig iron.

Lincolnshire.—Usually in this district coke is made with coals obtained from South and West Yorkshire, and to a small extent Derbyshire. These coals yield from 30 to 35% volatile matter, and the lean ores employed call for a consumption of about 27 or 28 cwt. coke per ton of iron made. One ton of coke requires, say, 44 cwt. coal, which yields 24,200 cub. ft. rich gas of 560 B.th.u. value.

Therefore for 1 ton Lincolnshire pig iron the heat value of gases is:—

27 cwt. coke per ton iron = 44 cwt. coal = 24,200 cub. ft. rich gas. 24,200 cub. ft. at 560 B.th.u. = 13.6 million B.th.u. gross.

$$27 \text{ cwt. coke} = \frac{150{,}000 \times 27}{20} = 202{,}500 \text{ cub. ft. at}$$

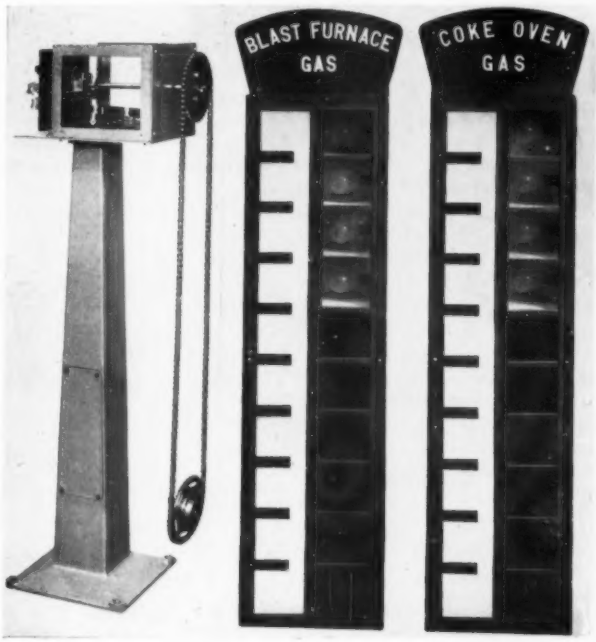
105 B.th.u. = 21·26 million B.th.u.

Total = 34·86 million B.th.u. gross,

or approximately in ratio of South Wales to Lincolnshire of 1 : 1·75.

On the other hand, the time factor is favourable for the South Wales example, as per furnace and per unit of time more iron is produced, which tends to somewhat level things up.

The precise use to which the two gases is put—either singly or combined—may vary according to the class of trade that has to be catered for by the particular plant. For instance, in Lincolnshire there is a plant making semi-finished steel material only. Here no reheating furnaces are required, and all the steel can be rolled direct from the ingot with the preliminary soaking-pit treatment. There



Electrically operated indicating and signalling system for application to waterless gasholders shown by Electroflo Meters Ltd. at the British Industries Fair.

are thus left sufficient gases available to heat the steel furnaces and thus produce ingots.

At Corby, in Northamptonshire, also where lean ores are employed, it is proposed to manufacture the steel by the basic Bessemer process. It is understood that the coke-oven gas here will be employed in the various furnaces necessary for tube manufacture.

These instances are given as an indication of the very diverse conditions that occur, and have to be met and dealt with on their merits. Generally, however, it can be stated that in many instances the desired plan of operations can only be arrived at by starting first of all (in the case of open-hearth plants) by fixing the tonnage of steel ingots required per week. From this one can determine how much pig iron is required; in some areas this will be determined again by the accessibility of steel scrap.

Generally, in a combined plant, such as we are discussing, a fair proportion of liquid metal will be used, but in any event a figure of pig iron will be decided upon. This may be of sufficient amount to satisfy the steel works, or it may be desirable to make a certain excess for sale. In either case the quantity of iron required will fix the amount of coke to be made, and will determine the size of the coke-oven plant.

In lean ore districts, owing to the larger volume of blast-furnace gas made per ton of pig iron, such gas will probably be employed for heating of the ovens owing to its superiority over rich gas for such a purpose, and thus freeing the whole of the oven gas for other uses.

The consideration of using this gas for making steel will depend upon—

(1) The quantity of both gases available according to the district conditions; and

(2) Whether mixed gases are to be employed with the ordinary steel furnace design; or
(3) Using coke-oven gas alone, employing special furnaces designed for such a purpose.

These matters settled, one will then be able to determine what to do with either gas that may still be surplus, and such points of usage as soaking and reheating pits, steam-raising, or internal combustion engines, all present themselves for consideration.

It will thus be seen that no general plan can be laid down as suitable for universal adoption, and whatever combination of circumstances may occur, and however the conduct of the scheme may be varied, one can only obtain the utmost limit of economy by taking precautions to ensure that wherever the gases may be employed, they shall be so under the best conditions known.

The correct and most suitable means of extracting as much of the thermal value of the fuel as possible will call for careful examination of waste or surplus heat at each and every point on the works where such is available.

In respect of the initial burning of the gases, true economy may only be effected by taking steps to ensure that the quantity and pressure are subject to as small a range of variation as possible. There have been many devices introduced from time to time to effect these objectives, but it can be said that the only effective means is by the installation of gasholders for the blast-furnace and coke-oven gases respectively.

In the past holders of the waterless type have been installed, of a capacity of 2,000,000 cub. ft. for blast-furnace gas, and about 500,000 cub. ft. for coke-oven gas. In the author's opinion, however, the better plan is to err on the side of full capacity, and to this end he would recgmmend 4,000,000 cub. ft. for blast-furnace gas, and 3,000,000 cub. ft. for coke-oven gas. These capacities would help to cope with some of the week-end gas which in many cases would be otherwise wasted, and would at all times give a fair degree of reservoir capacity to tide over periods of interruption to regular supply.

The ability to rely upon a constant quantity of gas of uniform pressure enables one to adapt and employ scientifically designed burners which may be relied upon to function to the greatest degree of economy. Such economy will be further enhanced by employing meters to indicate and register the exact quantity of gas used, and it has been found that such aids are much appreciated by the workmen and tend to effect a remarkable saving.

The gases will probably have to be carried to many different parts of the works, and in some instances to a considerable distance from the source of supply. In this case it is necessary for the workmen to be fully aware of the state of supply, and indicators disclosing the exact quantity of gases in the various holders must be installed at each point of use, and arrangements made for the priority of use in each department, in order to avoid unnecessary disturbance in case of interruption to supply.

The sources of waste heat are many and varied, and will differ with the conditions obtaining in different works. Apart from the coke ovens, where waste heat is generally taken care of in the by-product plant, the most obvious sources are open-hearth furnaces, soaking pits, exhaust steam turbines for electric power, or blowing plant for blast-furnaces, and where employed the waste gases from boilers. In these cases waste-heat boilers, economisers, and superheaters, naturally occur to one's mind; in addition, there is the heat radiated from the boilers, some of which can be used for preheating the air for the combustion of the gas for steam raising.

Recent developments in the design of gas burners, in some cases using the gas under pressure, point to the possibility of direct heating of soaking pits and reheating furnaces without the necessity of having regenerators or recuperators. In this instance, considerable economy may be effected as radiation and other losses consequent upon the use of regenerators are avoided, and any excess of heat after dealing with the ingot can be taken care of by waste-heat boilers.

In general, the principle of employing all the gases evolved from the coke-ovens and blast-furnaces, once adopted, tends to bring the plant under a condition where, by employing measuring and recording instruments, much valuable data can be accurately and easily ascertained, and from the data obtained further economies may be arranged for.

Such a system places the whole plant under direct and visible scientific control; disturbances in one department can be checked at source, and their effect upon other parts of the works definitely assessed.

An instance of this occurred recently: for the better control of the heating at the coke ovens, where blast-furnace gas was employed, a recording calorimeter was installed to register variations in the B.th.u. value of the furnace gas. These fluctuations are usually gradual and fairly small in extent, and any sudden increase in heat value of the gas points to some definite disturbing factor. In this case it is almost always found to be due to small quantities of water finding their way into the blast-furnace, usually from a leaking tuyère or cooler. The calorimeter has on more than one occasion intimated a leakage of this nature before the blast-furnace man had been able to notice it by any ordinary evidence. It has thus enabled a repair to be effected before any ill-effect had resulted.

In conclusion, the full and complete utilisation of the gases and waste heat on a plant produces a very real and substantial contribution towards reduction of working costs, eliminates guesswork to a great extent, enables absolutely scientific control to be applied at each and every department of the works, and enables the management to observe and control almost hour by hour all the various operations in different parts of the plant.

"Journal of the Institute of Metals." Volume LII.—"Proceedings."

THE latest issue of the *Journal of the Institute of Metals* is in effect a "silver jubilee" number, in that it contains a record of the Institute's twenty-fifth anniversary meeting recently held in Birmingham. It incorporates the papers read at that meeting and a verbatim account of the discussions. The papers—fourteen in number—cover a wide field of metallurgical work. They begin with one by Dr. W. Rosenhain, F.R.S., in which he traces—quite appropriately at such a gathering—"Some Steps in Metallurgical Progress, 1908-33." Dr. Rosenhain was one of the three contributors of papers at the recent meeting who had presented communications to the Institute at its first meeting—also held in Birmingham—a quarter of a century ago. The other authors thus distinguished were Dr. G. D. Bengough, whose paper on magnesium alloy protection is reproduced in the volume under review; and Dr. O. F. Hudson, whose communication, similarly reproduced, is entitled "Wear in the Polishing of Plated and Other Surfaces." Many of the other papers deal with subjects of special importance to those engaged in the metal industries of the city in which the silver jubilee meeting was held. Notable among these is Mr. W. R. Barclay's autumn lecture, entitled "Twenty-five Years' Progress in Metallurgical Plant," in which he reviews developments in melting and casting equipment, rolling mill machinery, rod and wire-drawing plant, and auxiliary equipment—the latter covering particularly annealing furnaces and smaller metallurgical plant. Mr. Barclay's lecture is illustrated by a finely reproduced series of 32 plates, which, together with many other practical papers, serve to make the present volume a particularly useful one for metallurgists and engineers.

Pp. 255. 50 plates. Clöth. Edited by G. Shaw Scott, M.Sc., F.C.I.S. London: The Institute of Metals, 36, Victoria Street, Westminster, S.W. 1. Price 31s. 6d.

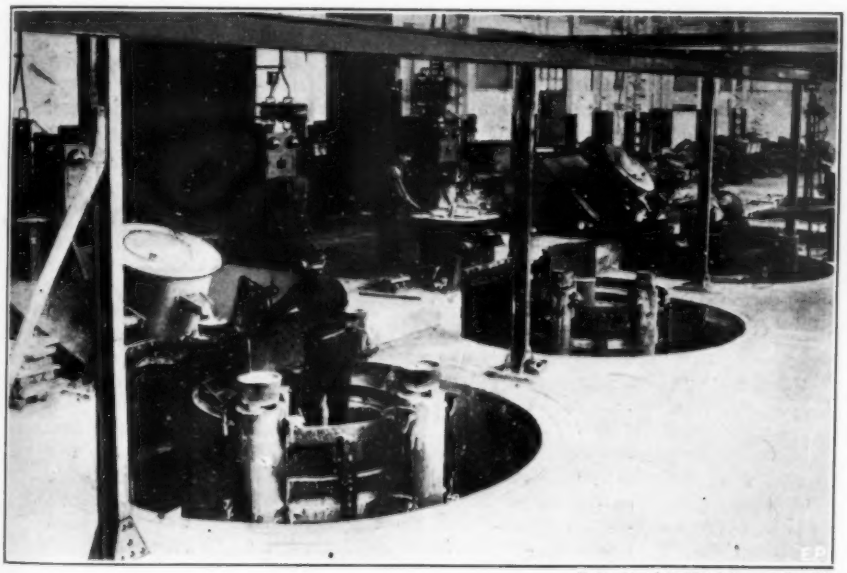
Progress in the Industrial Application of Copper and Its Alloys

By J. W. Donaldson, D.Sc.

Developments in the refining and purification of copper are discussed; the welding and brazing of copper and the industrial uses of this metal are described. Attention is also directed to the increasing importance of certain copper alloys and to recent developments in special alloys.

THE developments which have taken place during recent years in the production of copper have been very marked, particularly in the mining, treatment, handling, and smelting of copper ore, and in the refining of the finished product. To metallurgists and engineers, who are interested in the industrial applications of copper and its alloys, the various developments which have taken place in the refining and purification of the metal are of most importance. In the alloying of all metals, the influence of small amounts of impurities in general have very undesirable effects, and it is the realisation of this fact which has led to some very important researches.

In the laboratory the influence of impurities on copper has formed the subject of a series of important researches carried out at the National Physical Laboratory for the British Non-Ferrous Metals Research Association. In these investigations, which were made on fire-refined copper, consideration has been given to the presence of bismuth, and how far its injurious properties can be neutralised by the presence of oxygen or by the combination of oxygen and arsenic or oxygen and antimony. As a result of these experiments, it has been clearly shown that bismuth, in amounts which would be injurious if present alone, is neutralised by the above combinations,



By Courtesy of the Electric Furnace Co., Ltd.

Battery of Ajax-Wyatt furnaces on non-ferrous metal production.

By Courtesy of the I.C.I. (Metals), Ltd.

Wire-drawing machine of the latest design.

Investigations on the influence of impurities on copper have not only been made on an industrial scale with the view to improving copper for practical applications and for alloying, but they have also been carried out in the laboratory in order to determine the influence which very small quantities of such impurities have on the metal. The experiments have not only been conducted on electrolytic copper of a high degree of purity, such as is used for electrical purposes and high grade alloys, but work has also been done on "best select" or fire-refined copper which is used very extensively in industry.

An example of the first type of investigation is the production on an industrial scale of oxygen free copper of high conductivity. This has been achieved not by the use of deoxidisers but by keeping the metal free from oxygen during the smelting process, and protecting it from oxidation during melting and casting. The ductility of oxygen-free copper in the form of hard-drawn and soft-annealed wire respectively is stated to be 80 and 85%, as compared with 50 and 75% for ordinary electrolytic copper. It is also interesting to note in the preparation of copper alloys containing zinc that high-purity zinc has been prepared on an industrial scale by the New Jersey Zinc Co.

and that in the absence of oxygen appreciable quantities of either arsenic or antimony are necessary to neutralise the deleterious effects of bismuth. If similar results can be produced on a large scale, then these researches will have a very important influence on the industrial applications of copper, since the bismuth content affects not only the use but also the buying and selling of many thousands of tons of copper annually.

Welding of Copper.

The welding of non-ferrous metals usually presents more serious difficulties than are encountered in the welding of steel, and consequently has not had the same practical applications. During recent years, however, the welding of copper has been practised with a considerable degree of success, and improvements are to be noted both in technique and practical developments.

When compared with steel, copper possesses a very much higher thermal conductivity, and consequently a higher welding temperature is necessary. It is claimed that this high temperature is best obtained by use of the electric arc, by which a more intense local heat is obtained than when using the oxy-acetylene flame. The temperature

obtained by either method, however, is not sufficient for good welding, and a certain amount of preheating is necessary. By using the electric-arc greater speed of deposition is obtained, and there is a freedom from contamination by gas products, which is of extreme importance, as the presence of such impurities, particularly of oxides, leads to porosity and defective welds. It is stated that the presence of 0·01% of oxide in copper is sufficient to produce trouble. In addition to technique, the welding of copper has been made of practical importance by the use of properly deoxidised copper. To prevent oxidation, coated electrodes are used, having approximately the same melting point as copper, and usually containing 0·5% of silver.

With properly deoxidised copper, suitable electrodes and proper manipulation, very satisfactory results are now obtained, particularly when copper is welded in a horizontal position. Such welding has been principally applied to the construction of locomotive fire-boxes, and to a lesser extent in the manufacture of copper vessels for certain industrial processes, and in the repair of such vessels.

When dealing with the welding of copper, reference might also be made to progress in copper brazing. The brazing with copper in an atmosphere of hydrogen, is a process which is being increasingly used in America and Germany, and to a lesser extent in this country. Steel articles to be brazed are charged into an electric furnace in which is maintained a hydrogen atmosphere or a controlled atmosphere of hydrogen and carbon monoxide, and copper in suitable form is placed in close proximity to the parts to be joined. The temperature of the furnace is raised to about the melting point of the copper, and the molten copper, or an alloy of copper with nickel and zinc, flows into the seams by capillary action. Industrial applications of this method of brazing are the manufacture of tungsten carbide tools, the joining of certain automobile parts, such as hydraulic brake pipes, and the manufacture of tubing for use in refrigerating machinery, oil, and pipelines. In the manufacture of internal combustion engines, such parts as cylinder covers, piston heads, and fuel lines, have also been constructed by this process.

Industrial Uses.

The use of copper in the pure state is still principally confined to the electrical industries, at least 40 to 50% of the copper produced annually being used for such purposes. There are indications, however, that copper is being used to replace other metals, alloys, and materials for a variety of purposes. During the last few years, owing to its low price, copper pipes have been increasingly used to replace iron and lead service pipes. A considerably longer life is obtained from such pipes, which largely compensates the extra cost, and the use of copper for such purposes is likely to increase in the future.

Copper is also suitable for permanent use in exposed places, due to its well-known property of resisting corrosion. On this account it is being used particularly in the United States and in many other countries for roofing purposes. It is not only its resistance to corrosion and other physical properties which render it especially suitable for such a purpose, but also its uniform contraction and expansion, and many systems are now in vogue using thin copper sheets for roofing.

There is a definite trend in the United States to a more extended use for copper in the manufacture of cooking utensils and vessels. More copper is also being used in the form of tubes, pipes, and sheets in the food industries; in refrigeration; in heating appliances; in certain forms of transport, although in this application it has to compete keenly with aluminium; in railroad electrification; and in parts and fittings in building construction.

Alloys for Condenser Tubes.

The alloys of copper and nickel containing from 20 to 30% of nickel, and generally spoken of as the cupro-nickel alloys, have during recent years been used in increasing quantities industrially for condenser tubes, both for marine purposes and for land plant. The cost of such tubes are undoubtedly high, when compared with 70 : 30 brass tubes, but their resistance to corrosion gives them a longer life and definitely reduces condenser troubles, and thereby more than compensates for the increased initial cost.

During the last ten years cupro-nickel condenser tubes have been fitted in ships sailing over practically all the sea routes of the world, and have withstood successfully the various kinds of water to which they have been subjected. Such tubes have been fitted not only in the British, American, and continental navies, but also in all the large mercantile fleets. As an example of the confidence which such tubes have inspired, is the recent statement that, in the new cruiser and six destroyers for the United States Navy, 330,000 lb. of cupro-nickel condenser tubes, having a composition of 75% copper, 20% nickel, 5% zinc, are to be fitted.

Another alloy which is being used for condenser tubes is the alloy developed by the British Non-ferrous Metals Research Association, and known as aluminium brass. This alloy contains approximately 76% copper, 22% zinc, and 2% aluminium, is strong and ductile, has a high resistance to corrosion, and good film-forming properties. It has become of industrial importance, due largely to improvement in foundry technique, resulting from the introduction of the Durville method of casting.

In referring to improvements in foundry practice, it might also be stated that there have also been improvements in other directions. In the manufacture of condenser tubes there has been distinct progress in manipulative methods, and it is now possible to extrude any alloy, whether ordinary brass, cupro-nickel, or aluminium-brass, into tubes at speeds much greater than those used previously.

Aluminium Bronzes.

A series of copper alloys which have become of increasing importance are the alloys of copper and aluminium. These alloys, generally known as the aluminium bronzes, have been known for a considerable time, but have not been generally used for engineering purposes until recent years. This was largely due to the fact that' apart from small die castings, it was very difficult to obtain sand castings of such alloys. The tensile properties of the aluminium bronzes were also unsatisfactory, particularly the yield-point.

As a result of progress in foundry technique and the slow and steady filling of moulds by the Durville process already referred to, it has become possible to obtain sound castings and ingots of these alloys. Such ingots can be rolled, drawn, forged, or extruded without any detrimental results, as a result of the absence of aluminium oxide and shrinkage and gas cavities.

The mechanical properties have also been improved by selecting suitable proportions of aluminium for the different purposes for which the alloys are intended, whether they are to be used for forging, heat-treatment, or wire-drawing, and by the addition of other elements, such as nickel or iron or both in small proportions. The addition of 4 to 7% of nickel to an aluminium bronze has a marked influence on the yield-point, breaking stress, and ductility. Resistance to fatigue and alternating stress are also considerably improved by such addition, and the strength at high temperatures is improved and maintained.

The result of such foundry treatment and alloy additions is that aluminium bronzes are now being used on some large scale applications, where hitherto they were only used in the manufacture of small die castings. Their use has also been extended to branches of engineering from which they were previously excluded, and parts such as propellers, worm-wheels, gun mountings, bridge bearings, are now being manufactured of these alloys. They are also finding increasing application in the aircraft and automobile industries for parts such as valve seats. Modifications of their properties by nickel also increases their density, and renders them specially suitable for pressure work, with the result that their use is increasing in equipment working under severe hydraulic pressures.

High-duty Copper Alloys.

A development in the production of high-duty copper alloys during the last few years, and one which has very marked effects on their properties, is the introduction of small amounts of nickel to such alloys. In rolling-mill brasses, which contain a high percentage of lead, a small addition of nickel not only produces a better distribution of the lead, but also increases the toughness. Nickel bronzes containing 5% nickel and 10% lead have also been found to be very suitable for high-speed parts, working in contact with hard nitrided steel.

An alloy containing 80% copper, 10% tin, and 10% nickel has also been recommended, and has given satisfaction for such parts as pump liners and slide valves, working with a reciprocating motion and where a fair degree of hardness is necessary. The addition of nickel to high-tensile brass in quantities varying from 2 to 2·5%, has also been found to be beneficial by increasing the ductility of the alloy and also its resistance to erosion. Industrial applications of high-tensile brass containing nickel are its use for marine propellers, turbine impellers in hydro-electric plant, and highly stressed electrical castings where non-magnetic properties are desirable, as well as strength and resistance to corrosion.

Special Copper Alloys.

A series of alloys on which a large amount of work has been done during the last year or two, particularly in Germany, are the alloys of copper and beryllium. When beryllium is added to copper, usually in the form of a 10% copper-beryllium alloy, in amount varying from 2 to 2·75%, a series of alloys is obtained, which, on heat-treatment and age-hardening, have remarkable properties both as regards strength and hardness. Copper containing 2·5% beryllium, when annealed at 800° C. and quenched in water, then age-hardened at 250° to 300° C. for varying periods, has a tensile strength varying from 65 to 80 tons per sq. in., and a Brinell hardness of 350 to 400. Good castings are obtained from such alloys, free from porosity, and they have a high electrical conductivity.

So far there have been few practical applications for the copper-beryllium alloys, principally due to the high price of beryllium, but, in Germany, attempts are being made to use them for industrial purposes. The copper-beryllium alloy just mentioned is stated to be particulary suitable for the manufacture of springs, both in spiral and laminated form, as it is non-magnetic, less liable to break than steel, and does not corrode. In the manufacture of springs and driving parts for watches and clocks, it is finding an increasing application.

Interesting investigations have also been carried out on the age-hardening or precipitation-hardening of copper-nickel-aluminium alloys which have also shown susceptibility to such treatment, and two interesting papers on these alloys were read at the recent autumn meeting of the Institute of Metals. From these experiments interesting and valuable data have been obtained which may lead to important industrial applications of these alloys in the near future.

Recent developments resulting from the successful mechanical working of hard and brittle alloys are the production of wrought articles from an 8% phosphor-copper alloy, as the result of investigations carried out in Germany and also in this country. The articles produced include rods, tubing, sheets, cooling worms, and pump parts, and are stated to be hard and strong, resistant to shock, and to machine well. It has also been indicated by the German investigators that there is a possibility of working successfully other brittle alloys of copper—namely, those with arsenic, antimony, and silicon. In this country a copper-silicon alloy containing 3 to 4% silicon with or without 2% iron has been in use for some time, both in the form of castings and also in the worked condition, and has replaced gunmetal and high-tensile brass for many parts.

A New Series of Copper Alloys

Remarkable claims are made for a new series of copper alloys which have the property of hardening and strengthening by suitable heat-treatment.

KUNIAL is the name which has been given to a series of new copper alloys discovered in the laboratories of I.C.I. Metals, Ltd. The remarkable feature of these new alloys is that by simple heat-treatment their hardness, strength, and other mechanical properties can be very considerably improved.

The discovery of a new alloy with properties of outstanding interest is in itself a rare but important event of metallurgical interest. The importance of the present discovery is that it concerns not merely one alloy alone, but a whole new series of alloys.

The series covers Kunial brass, Kunial copper, Kunial nickel silver, and Kunial bronze. All the commonly used copper alloys are annealed and softened by raising them to temperatures in the region of 400° to 600° C. It is therefore remarkable to know that similar heat-treatment may treble the hardness and double the tensile strength of the Kunial alloys. These alloys can be extruded, rolled, drawn, and cold-worked exactly in the same way as ordinary brass for the production of rod, wire, tubes, strip, and sheet.

Kunial brass, which is one of the most important of the series, is an alloy of copper and zinc, together with other added elements which impart to the metal its remarkable properties. The copper and zinc contents may be varied within wide limits, thus modifying to some extent the basic properties of the alloy, but in all cases the unique property of hardening and strengthening by suitable heat-treatment is retained.

From the accompanying table it will be seen that by heating the soft-quenched alloy to 500° C., the diamond pyramid hardness is increased by about 100, the limit of proportionality and proof stress are multiplied fourfold, the tensile strength is increased by 14 tons per sq. in., whilst the elongation is only halved—a truly remarkable change. If the cold-worked alloy is heated to 450° C. it will be noted that the diamond pyramid hardness is increased by about 40, the limit of proportionality and tensile strength are considerably increased, but, what is also remarkable, the increase in strength is accompanied by an increase in elongation. Whilst these figures refer specifically to a Kunial brass strip, they are typical of the changes in mechanical properties which take place in all Kunial alloys when suitably heat-treated.

MECHANICAL PROPERTIES OF KUNIAL BRASS.

The figures given below will illustrate the remarkable properties of a Kunial brass strip containing 72% copper.

Condition.	Diamond Pyramid Hardness.	Limit of Proportionality, Tons per Sq. In.	Proof Stress.		Tensile Strength, Tons per Sq. In.	Elongation % on 2 in.
			0·1%.	0·2%.		
Soft (as quenched from 900° C.)	69	4·4	3·3	5·7	22·8	61
Soft and heat-treated at 500° C.	161	17·2	22·0	23·0	36·6	29
Soft and cold-rolled (50% reduction) ..	198	22·2	34·8	37·4	39·7	6
Soft, cold-rolled (50% reduction) and heat-treated at 450° C.	240	36·8	45·3	47·2	48·5	11

At first sight these remarkable changes in mechanical properties brought about by heating alone may appear unbelievable, but in reality they are similar to those met with in such alloys as duralumin and beryllium copper.

Reviews of Current Literature.

Industrial Accountancy

IT has been said that the object of industry is to set up economic ways and means of satisfying human wants and in so doing to reduce everything possible to routines requiring the minimum amount of human effort. Through the use of scientific methods, extended to take account of modern statistical concepts, it has been found possible to set up limits within which the results of routine efforts must lie if they are to be economical. Deviations in the results of a routine process outside such limits indicate that the routine has broken down and will no longer be economical until the cause of the trouble is removed. Only by adopting such methods is it possible to control the manufactures and, incidentally, the administration of the works. Even for a single product a control system may be complex, but to arrange scientific methods for works in the iron and steel industry employing over 5,000 persons is obviously of a complex character ; yet this book describes in detail a system in operation in one of the largest organisations in the heavy industries.

However desirous it is to control the quality of manufactures, modern economic conditions demand very careful study of cost accounting, particularly in the iron and steel industry with its various and diverse operations. In fact, the necessity for uniform costing systems is implied in the scheme of reorganisation in this industry, action on which has already been taken. Obviously, to effect orderly progress of the industry, accuracy, and control costing are essential requirements. The British iron and steel industry reached maturity in the days of individualism, and the continuance of free access to foreign supplies of raw and semi-finished materials has resulted in its retaining much of its complex individualistic organisation long after its competitors in other countries have become highly national ised. The scheme of reorganisation to be presented by the National Committee will undoubtedly embrace some form of nationalisation, and uniform costing systems will be of primary importance ; the publication of this book, therefore, is very opportune.

Industrial accountancy, as presented by the author, embraces cost accounting, financial accounting, planning, progressing, and works administration ; and every paragraph is of an eminently practical nature. The system described is applicable to a steel works or any analogous concern operating on a process basis. The principles employed practically abolish office drudgery ; much of the work being mechanised by calculating, listing, and book-keeping machines, combined with the scientific use of code numbers. The utmost use is made of original information by using a unit card and unit information. The principle of programming is applied to office work and office records. The common functions are centralised, and control of the recording in the works is placed in the hands of an office administrator. The cost of idle plant is debited to a " non-productive " account. The importance of standards to modern management are stressed throughout the book ; they can be set for each stage of manufacture, and can be compared with the actual costs daily and weekly.

Obviously, the value of cost figures depends on their accuracy and the speed with which they can be presented. Interest can be stimulated and immediate action taken, if costs are reported quickly. The method of achieving this desideratum is fully described by the author, the chief features of which are the speed with which results are obtained—for example, the pay roll for 5,000 men can be completed in three hours ; the weekly costs for all departments and all products can be completed in six hours ; the monthly profit and loss account for each product in each department can be completed on the first day after the end of each month or period ; all costs and profit and loss results can be interlocked and balanced with the financial accounts ; and the costs of every product and every operation can be compared with standard costs, which vary with capacity and quality of product. It is claimed that the system can be installed at no extra cost, and may result in effecting reduction in existing office staffs.

The system described in this book is in operation at the United Steel Companies, Ltd., and, although it is written in terms couched in the language of the iron and steel industry, the scientific methods employed can be applied with advantage to the cost systems of other industries, but for the iron and steel industries in particular this book will be acknowledged as a standard work on accountancy. The author is essentially practical, and does not waste time on non-essentials ; he is to be commended for the lucid manner in which he presents the system to the reader. The book is a valuable addition to very meagre literature available on accountant's work in industry, and the members of staffs in works that have any pretentions to organised production systems should not fail to give it careful study.

By H. A. Simpson, F.C.W.A. Published by Longmans, Green and Co., Ltd., 39, Paternoster Row, London, E.C. 4. Price 10s. 6d. net.

Thermostats and Temperature-regulating Instruments

THIS useful little volume gives information on numerous types of thermostats, descriptions of which are somewhat scattered in technical publications. As is fairly well known, the thermostat is an automatic apparatus or instrument for regulating temperatures, or for giving warning of an undue rise of temperature. It is particularly a device in which the expansion of a metal or a volume of gas acts directly or indirectly through an electric circuit upon an alarm, or to control a source of heat. It is used in conjunction with fire alarms, for regulating the positions of furnace dampers, controlling steam pressures, and other applications.

In one form, for controlling the temperature of a furnace, it consists of a strip of bi-metal, which is composed of metals having unequal co-efficients of expansion, and carrying at one end an arm which, when in an operative position, engages one of a pair of contacts for opening and closing electric circuits controlling dampers. Variations in the temperature of the strip, which is exposed to the source of heat, close one or the other of the circuits to open or shut the dampers, and thus control the temperature of the furnace. The mechanism really consists of two parts—one for detecting temperature changes in the system under control, and measuring their magnitude, and the second for correcting these changes so as to maintain the system at a constant temperature.

The importance of having the proper type of thermostat for particular requirements cannot be over-emphasised, and the author has performed a useful service in assembling such a wide range in this book. He has also been careful to explain the principle of each type, to supply data, and to give practical information regarding the applications of different forms. The book is well illustrated, and can be regarded as a welcome work of reference on the subject.

By Roosevelt Griffiths, M.Sc. Published by Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C. 2. Price 10s. net.

Development of Materials for Poppet Valves

(*Continued from page* 116)

of the alloy which should be used, alloys which are too hard are stated to give trouble from cracking. It is a fact, however, that inserts faced with Deloro Stellite No. 10 having a diamond pyramid hardness in the welded layer of 630–650 have been successfully used in production without giving any trouble from cracking. It may be of interset to note that welded facings of this hardness can be successfully turned by tools of the cemented tungsten carbide type.

(*To be Continued.*)

The Development of Materials for Poppet Valves

By C. C. HODGSON

In this article the author discusses the history and development of valve materials, valve requirements, and the difficulties encountered in use.

THE history and development of the materials used for poppet valves, particularly for the exhaust valves of petrol engines, is of considerable interest. The interest of the designer is probably centred in the more exacting conditions which he may with confidence impose. The user benefits through the improved operation which he obtains as a result of greater reliability and longer periods which may be allowed without attention, although it is doubtful if in many cases he stops to consider this at all. For the metallurgist perhaps the chief interest lies in the variety of the alloys which have been applied towards a solution of the problem set by the necessity of providing a material which should be able to operate for long periods at temperatures up to a maximum of some 800° to 900° C.

During the early days of the motor industry the material for exhaust valves did not receive much attention. Although valves gave considerable trouble, particularly in the matter of breakages, the level of their performance was artificially raised by comparison with the many other troubles.

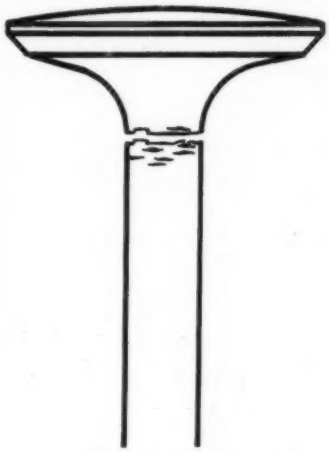


Fig. 1.—Normal type of valve breakage, the result of fatigue.

Fig. 2.—Crack encircling top of valve head, the result of stress concentrations at sudden change of sections.

Fig. 3.—Badly burnt valve, 3% nickel steel.

Fig. 4.—Burnt valve, austenitic heat-resisting steel.

As the general reliability improved and the petrol engine passed from the pioneer stage to that of utility more attention was paid to improving the life of the exhaust valve. The exigency of the Great War gave an enormous impetus to research on this problem, and in the post-war period the further demands of aeroplane engines and also those of heavy commercial vehicles acted as additional stimuli.

In the course of thirty years probably hundreds of different alloys have been used in an endeavour to find an ideal material. Almost the whole of this work has been done with steel, although for a time cast iron was used and a limited number of experiments has been made with non-ferrous alloys. Many steels have played a successful part in this development, to be succeeded in turn by others having more suitable properties as the conditions became more severe or the demand for an increased length of life more exacting. Throughout this period of development the balance has been kept swinging by the demands of the engineer on the one side and the efforts of the metallurgist on the other. The variety of the materials used has been so large and the changes in practice have been so varied that a discussion of the history and development of valve materials cannot conveniently be separated from some reference to valve requirements and to the difficulties encountered in use. Unfortunately, this subject if treated exhaustively would require considerably more space than can be devoted to it in this article, and it must suffice, therefore, to consider it briefly and in a general manner.

The essential requirements for a valve can be very simply stated: firstly, it must not break in service and, secondly, must be capable of maintaining a gas-tight seal. These conditions are not difficult to meet for valves operating at comparatively low temperatures. It is for the highest working temperature that the provision of a single material which shall be entirely satisfactory remains a problem still to be solved. The exhaust valve is heated when closed by the flame in the cylinder during the firing stroke, and when open during the exhaust stroke it is subject to the full blast of the exhaust gases. Cooling is obtained through the valve seat and the stem, whereby heat is transferred to the cylinder head or the guide. The heat dissipated will depend on the heat conductivity of the valve material, the area of the surfaces available for cooling, the heat conductivity of the materials used for the cylinder seat and guide, and the difference in temperature between these and the valve.

It is well-known that the design of both engine and valve has a considerable influence on the performance of the latter. For example, a valve with a heavy head and a thin stem will be likely to give trouble both from burning and breakage. Not only is it weaker in the neck initially than a valve having a lighter head and stem of more generous dimensions, but it will be obvious that because of lack of metal in the stem to conduct away heat both neck and head will run hotter, thus further reducing the strength and increasing any tendency of the head to burn.

Numerous devices have been used in an endeavour to assist the cooling of the head of the valve such as providing a hollow stem partly filled with some substance having a melting point considerably lower than the working temperature, for example the salt cooled valve using a eutectic mixture of the nitrates of potassium and lithium. As the temperature of the valve rises the filling melts and the agitation of the liquid caused by the movement of the valve assists in keeping the head cool, heat being transferred from this part to the stem by the heated liquid.

More recently metallic sodium has been substituted for salt mixtures. Another method of increasing the heat flow along the stem is to provide a core of high conductivity material such as copper. This method does not appear to have been used commercially in this country; some experiments with valves of this type have been rather disappointing. It is unfortunate that all the special steels developed for valves possess rather poor heat conductivities.

Broken valves may often have serious consequences. At one time they gave considerable trouble, but with modern steels of the correct type and good quality a broken valve should be a rare occurrence. With the exception of occasional failures due to the use of unsuitable or defective material valve breakages are of the fatigue type. The hottest part of an exhaust valve is at the radius and neck under the head, and it is at this place that the normal type of breakage occurs, as shown diagramatically in Fig. 1. Although such failures generally follow the simultaneous operation of more than one of the factors bearing on this problem, the determining cause is the temperature at which the valve operates. Even the influence of tool marks left after machining would not be likely to cause failure were it not for the serious loss of strength suffered by all steels at high temperature.

The ideal method of classifying valve steels would be to test them under conditions similar to those met with in service. The difficulties of putting this counsel of perfection into practice are obvious, and very little work has been published on fatigue or endurance properties at high temperature. A series of steels may be arranged according to their tensile strength determined under standardised conditions at some temperature equivalent to the maximum which a valve will attain in service. Such a list although bearing no direct relationship to their endurance does give valuable information. In the absence of data more nearly related to service conditions the hot tensile test remains a valuable guide to the probable resistance of a steel to fatigue failure.

The stress imposed by the spring tension would not, of itself, be sufficient to cause the valve to break if it were opening and closing in the orderly way for which the cams are designed. At high speeds instead of the valve returning to its seat quietly it probably returns with considerable force. Side thrust and too large a clearance between stem and guide may cause the valve to hit one side of its seating before being pulled into place by the spring. It can be pictured that the combined effect of shock and bending imposed by such treatment may set up a considerable fatigue stress at the neck. Mention should be made of failures which sometimes occur at the opposite end of the stem where provision is made for the spring fixing. Fatigue cracks leading to failure may be set up here either as a result of weakness through the excessive reduction of section, by corners which are too sharp acting as stress raisers, or lack of rigidity of the spring anchoring device. At the head end of the valve sudden changes of section either in the shape of the top of the head, or even in some cases of the slot provided for the grinding tool, have been known to forn the starting places of fatigue cracks. The valve shown in Fig. 2 is an example of a fatigue crack starting as a result of a sharp change of section; the valve head has been partly cut in two and a portion broken away so as to disclose the annular nature of the crack.

It has already been stated that there are exceptions to the general statement that valve breakages are due to fatigue. The use of steel which is exceptionally brittle, or becomes so in service might result in a breakage as a result of shock. All the present day valve steels are satisfactory in this respect if properly treated before being put into service. A high notched-bar value in a valve steel is not essential. Although a desirable property it is useful to remember that a number of successful valve steels have, either originally or after service, quite low impact values if judged by the standard of ordinary structural steels. A low notched-bar value should not therefore be sufficient to condemn a steel if its other properties render it suitable for service at high temperatures.

Our second essential requirement was that the valve must maintain a gas-tight seal. If there is a leakage of hot or burning gases during the firing stroke, when both pressure and temperature are higher than during the exhaust stroke, a burnt valve will follow sooner or later even with the best available valve steels. It is true that the special steels show a resistance to burning greater than that of their predecessors, the rate of burning is also slower and as a result damage is usually more local, but the difference is one of degree only. Examples of badly burnt valves made from ordinary and special steels are illustrated by Figs. 3 and 4. The materials are three per cent. nickel steel and an austenitic steel containing approximately chromium 18 per cent., nickel eight per cent., tungsten 3.5 per cent. and silicon 2.5 per cent. respectively. These two examples indicate what is likely to happen to a " blowing " valve if left without attention; admittedly the nickel steel valve is in a particularly bad condition but the two valves are a reminder of the difference between old and new materials and the improvement which has taken place.

The burning of a valve is generally associated with small cracks which appear on the seat. Unfortunately burning is seldom found at a sufficiently early stage for the valve to be salvaged. The special valve steels seem to be somewhat prone to small surface defects in the bar, these if present are generally detected in the forging but there must be some valves in which such defects are present on or near the seat. In some examples it is probable that the cracked seats are to be attributed to defects in the material which have escaped detection and subsequently opened out in use. However a broad view leads to the conclusion that most burning trouble is due to some condition which allows the passage of hot gas locally *before* the cracks are formed, for example such a condition might result from distortion, corrosion and the pounding of the valve into its seat amongst other causes.

Suitable design of the valves can do much to counteract the effects of warping, but adaptability of the valve to adverse conditions cannot successfully combat distortion or change of shape in the seat cut in the head of the cylinder. Resistance to wear plays an important part in connection with burning. If the stem (or guide) wears the clearance becomes excessive and there is then a danger of the valve striking its seat more or less violently in one place instead of coming down evenly. In time this may hammer one part of the valve face out of shape, leaving a space through which hot gas can pass during the combustion stroke.

Considerable trouble has been experienced during the last few years in some engines through the sinking of the valve seats in the head due to the more severe conditions of service. The loss of clearance may be sufficient to allow burning to start; another peculiarity of this malady is the transfer of metal from the block to the valve,sometimes causing sufficient irregularity of the surfaces to allow of the passage of gas. The use of alloy irons for the cylinder and head castings has sometimes reduced but not eliminated the trouble in those designs where it occurred. The solution has been found in the use of inserted seatings having characteristics distinctly different from those of the valve. This method of construction has of necessity long been standard in the case of aluminium-alloy heads. Many different alloys, both ferrous and non-ferrous, have been used but the choice of a material was often restricted by questions of the relative expansion of the head and seat, it was necessary to use materials for the seating having coefficients of expansion similar to or approaching thosr of the head with which they were to be used. A high initial hardness and the ability to retain this at elevated temperatures seem to be desirable properties, the requirements appear to be met most satisfactorily by stellite or similar alloys deposited with an acetylene torch on to a steel insert in the form of a ring, the seat being subsequently machined or ground on the deposited portion. There appears to be some difference of opinion as to the hardness

(*Continued on page* 114.)

Recent Progress in Non-ferrous Seamless Tube Manufacture

By Gilbert Evans

To review progress during the past twelve months from the non-ferrous tube manufacturers' point of view is not an easy matter, as the effect of the general revival in trade was not felt until the end of the year, but it is satisfactory to record that despite the difficulty in obtaining orders, the advance in scientific research and improvement in technique were more marked than in any previous period. In this article the author deals mainly with mechanical and engineering progress in the manufacture of tubes of various metals and alloys.

IN the rotary piercing process one of the outstanding features has been the success achieved in dealing with the difficult 70/30 alloy, due to extreme care in selection of the ingredients, methods of mixing, melting, and pouring, in the temperature control, and in the actual piercing. It is appreciated that at least two leading manufacturers had for some years past almost eliminated casting on sand cores in favour of the rotary process, and similar treatment has been successfully adopted by other Continental competitors. It is apparent also that a large field of exploration is opened up by the introduction in the rotary mill of motors of variable speeds, with a view to the adaptation of variable peripheral roll speeds to suit various alloys. It is generally agreed, despite the great advance in extruding methods, that the rotary process is to be preferred for diameters ranging from about 2 in. diameter upwards, while the extrusion method is preferable for the smaller sections. This latter observation does not apply to the manufacture of locomotive tubes, in which case the solid billet, pierced on a rotary mill, is of sufficient weight to yield two or three finished lengths of from 11 ft. to 15 ft. The expanding process has also been more universally adopted, and in this connection advance has been aided by the reconstructed arrangement of the guide rolls, as indicated in comparative Figs. 1 and 2. One of the chief defects of the old arrangement of single top and bottom rolls (Fig. 1) was the tendency of the reheated pierced shell to buckle or fold itself up in the wide space between the main rolls and either the top or bottom roll. This tendency to force the material out of its circular shape has been eliminated by doubling the number of guide rolls, as indicated at Fig. 2, a method which is self-explanatory.

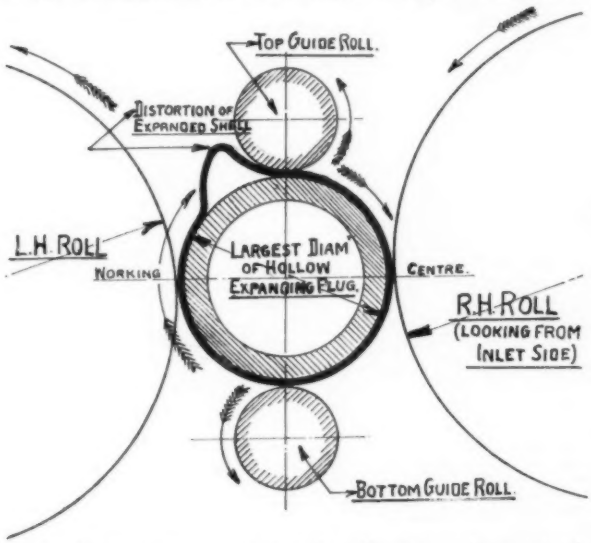


Fig. 1.—Incorrect arrangement of single guide rolls causing occasional buckling of shell.

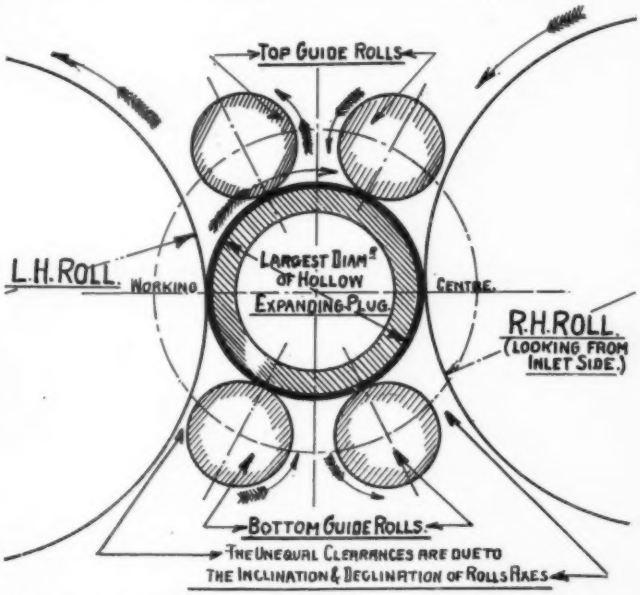

TOP GUIDE ROLLS
L.H. ROLL.
NORKING
LARGEST DIAM.r OF HOLLOW EXPANDING PLUG.
CENTRE.
R.H. ROLL. (LOOKING FROM INLET SIDE.)
BOTTOM GUIDE ROLLS.
THE UNEQUAL CLEARANCES ARE DUE TO THE INCLINATION & DECLINATION OF ROLLS AXES

Fig. 2.—Correct arrangement of guide rolls to prevent buckling of shell.

Reference must also be made to the adoption of automatic devices for the introduction of the heated solid round billet to the main rolls on the charging side, and the withdrawal of the piercing or expanding bat and mandrel on the outlet or discharge side. The latter device includes the delivery of the shell to the water bosh. This combination reduces the manual labour necessary to two or three operators, as compared with a full gang consisting of attendants for lubricating, furnaceman, sticker-in, plug hand, gate hand, extractor hand, and bosh hand. Particulars of the complete arrangement, which has been adapted with success on the Continent and in Japan, may be obtained from the author, as space does not allow inclusion here.

It has always been the object of the designers of rotary mills to deliver to the finishing bench department shells of a diameter and wall thickness suitable for drawing to the required finished size by a minimum of cold passes over mandrels and through dies, which method excludes the necessity of the expensive annealing and pickling treatments. A brief description of two reducing processes, which have and are receiving the consideration of manufacturers of both steel and non-ferrous tube manufacturers, will therefore be of interest. These inventions are placed by seniority, as it was from 1920 to 1923 that the author made his first successful experiments and filed provisional specifications covering same. As illustrated at Fig. 3, the design was a reversal of the conditions governing the initial piercing of the solid billet, and the introduction of the pierced shell to rolls so designed that the rates of the shell at its first contact with the *large diameter of the rolls* was maintained through the whole of the reducing process, until and after contact with the *small diameter of the rolls*, at the delivery or discharging end of the mill. The tool governing the ultimate inside of reduced shell may be of

plug design or take the form of a solid bar. In the latter case the reeling action of the guide rolls allow the bar to be free for removal on the completion of the operation, as at Fig. 3. The flexibility of the mill, arranged on similar lines to the piercing mill, covers all diameters from 10 in. down, and produces shells which may be cold drawn to

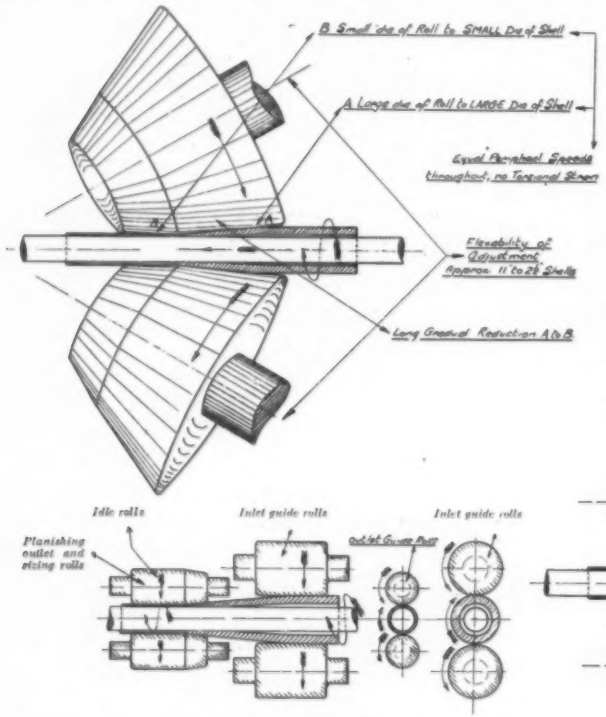

B Small dia of Roll to SMALL Dia of Shell
A Large dia of Roll to LARGE Dia of Shell
Equal Peripheral Speeds throughout, no Tangential Slip
Flexibility of Adjustment Approx. 11 to 26 Shells
Long Gradual Reduction A to B
Idle rolls
Inlet guide rolls
Inlet guide rolls
Planishing outlet and sizing rolls
Outlet Guide Roll

Fig. 3.—Plan and vertical sections of "Evans" patent rotary tube-reducing process.

finished diameter and gauge in two passes on the bench, with one heat-treatment and pickling.

The method shown in Fig. 4 is that adopted in the United States of America by Diescher, and is adapted to mills of higher peripheral speed than the main rolls, with the object of assisting the hollow shell in its progress through the reducing operation. Both the inventions referred to are sound and practical, and capable of considerable development, and as is obvious, are designed to collaborate with the piercing mill, being arranged in an adjacent and convenient position to the discharge or outlet end of that plant, to enable both operations to be carried out direct from the heating of the solid billet.

The Advance of The Extrusion Process.

During consideration of the progress of extruding methods as applied to the manufacture of non-ferrous tubes, the author was reminded of the reply of a Continental manufacturer of these hydraulic presses to an inquiry put to him in the course of a conversation. It was to this effect: "You will realise that improvements, especially in this type of machine are not made every day." Readers of METALLURGIA will recollect that the author had the privilege of describing in extenso and illustrating the Serck and Fried Krupp hydraulic extrusion press in the October (1933) issue, and now purposes to bring to notice the most recent type of mechanical power press made by Messrs. Taylor and Challen, Ltd., of Birmingham, through whose

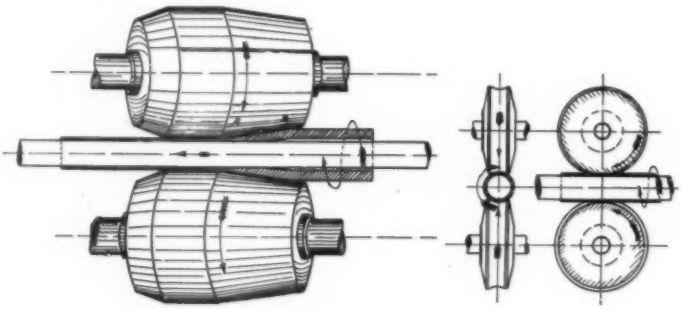


Fig. 4.—Plan and vertical sections of "Diescher" American tube-reducing and elongating process.

courtesy a general arrangement, and also details of the container, adjustable holder for piercing and extruding mandrel, and cutting-off tool, and ejection and removal of discard are reproduced; the last-mentioned operation

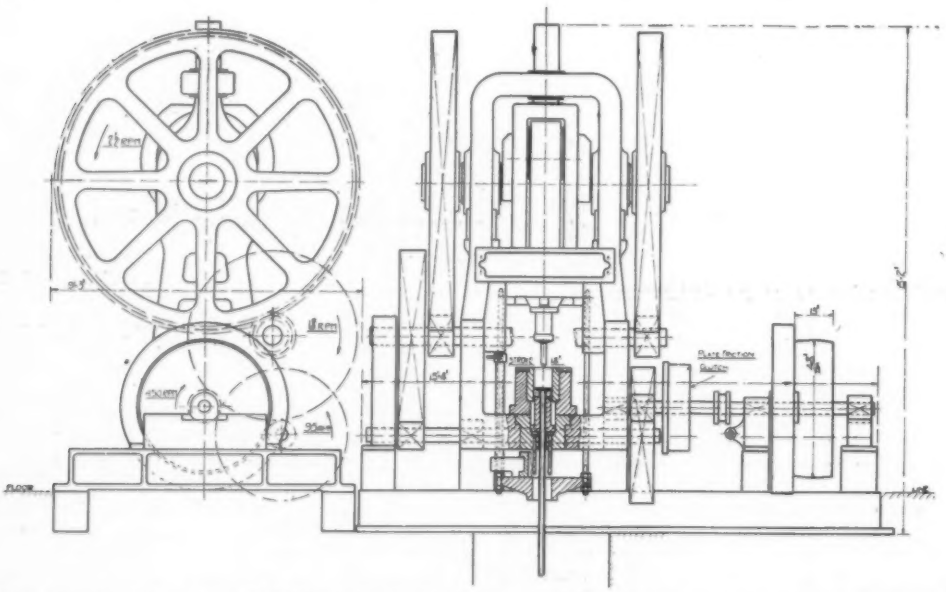


Fig. 5.—Recent type of mechanical power press adapted for tube extrusion. The pressure capacity of this machine is 600 tons.

the cross-barrel type of Mannesmann machines. The principles involved are mainly those set out in the preceding description, but, in addition, a series of mechanically operated grooved discs are introduced in place of the top and bottom guide rolls. These are driven to give a much allows a change of extruding die to be made at the discretion of the operator. The firm mentioned are the designers and manufacturers of deep-drawing presses for production of shell cases, etc., and the press under consideration is an adaption of their "790" tool. The ultimate

pressure exerted by the plant illustrated at Fig. 5 is 600 tons. The first motion shaft, in which a suitable flywheel is mounted, is belt driven at 450 r.p.m., also arranged on this shaft is a plate friction clutch under the operator's control. In place of ordinary double gear, triple gear has been introduced, which ensures increased efficiency. With sections are self-explanatory, it is necessary to direct attention to the vertical stool forming a resistance to the pressure on the extruding die and also to the method by which the discard and die are brought within reach of the operator for removal and exchange respectively. This is accomplished by a bottom crosshead connected through

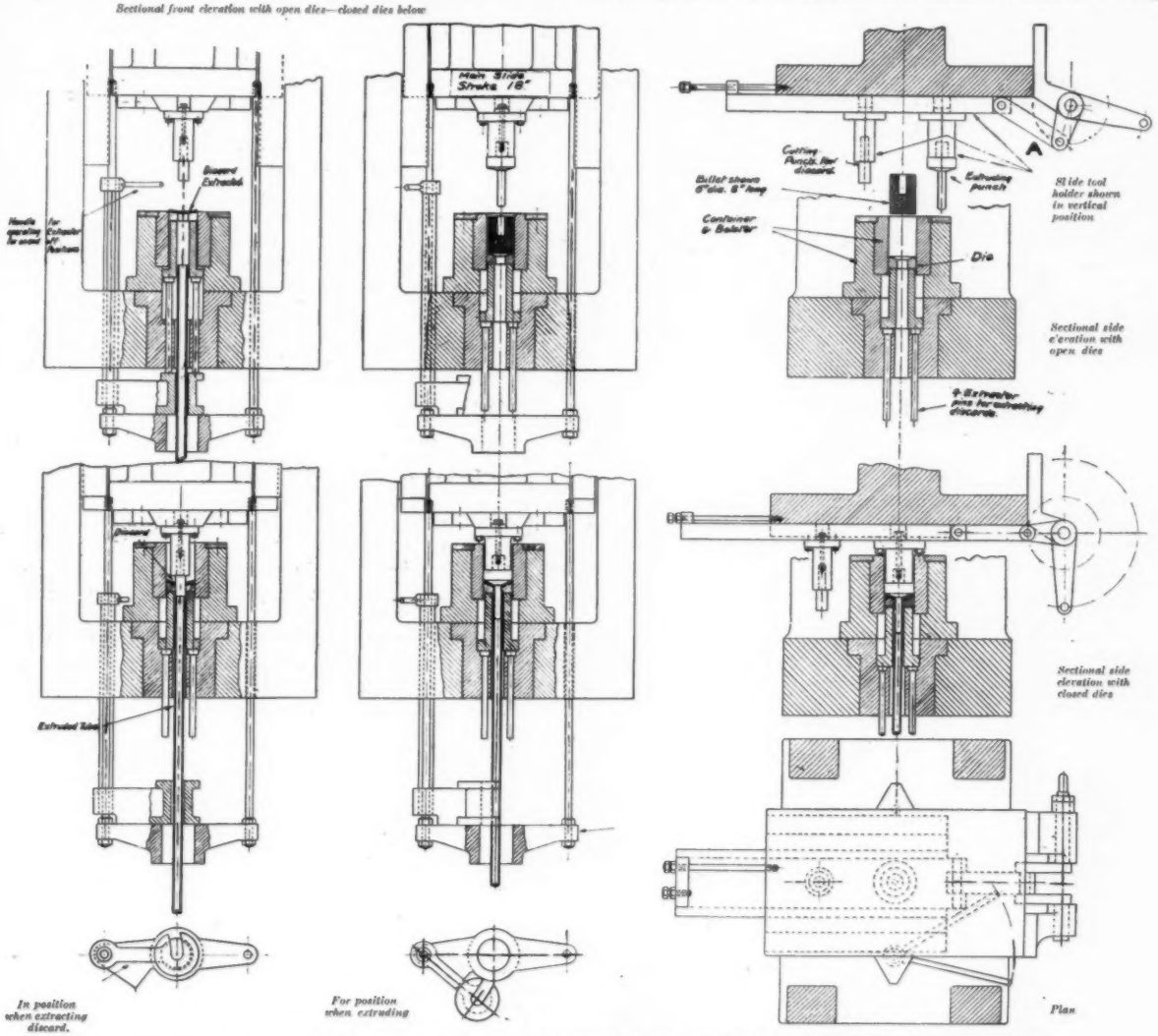

Sectional front elevation with open dies—closed dies below
Main Slide Stroke 18"
Discard Extruded
Handle operating for ejector at bottom
Extruded tube
In position when extracting discard.
For position when extruding
Cutting Punch for discard
Billet shown 6" dia. 6" long
Container & Bolster
Extruding punch
Slide tool holder shown in vertical position
Die
Sectional side elevation with open dies
Sectional side elevation with closed dies
Plan
A

Fig. 6.—Detail sections showing various tools and operations for extruding tube with the press shown in Fig. 5.

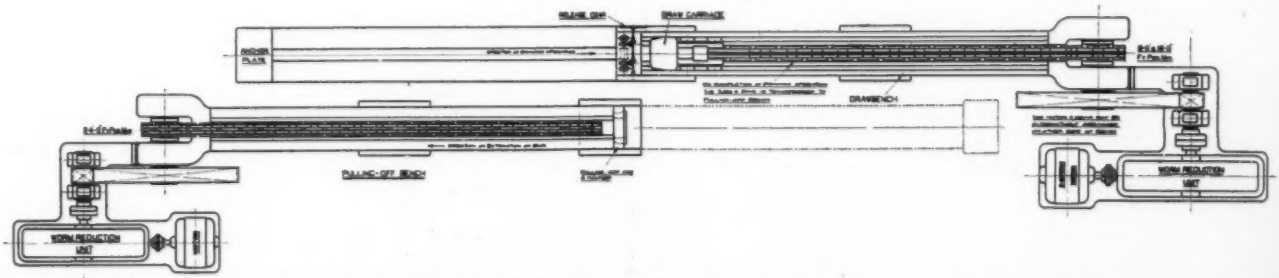


Fig. 7.—A new type of draw bench which solves the problem of unproductive handling when it is used for bar-drawing.

a stroke of 18 in., ample "daylight" or vertical working space is available. Reference to Fig. 6 will attract attention to an ingenious device in the shape of a sliding mandrel and cutting-off tool holder, the operating of which is made clear by progressing from indication letter A on right-hand top, reading thence to left and downwards, thence to left-hand and up. In so doing it will be necessary to study the full cycle of operation set out between the last two positions—viz., at bottom right. While the positional bolts to the table on which the adjustable mandrel frame is attached. It will also be noted that in the piercing and extruding operations the whole pressure exerted on the extruding die and its supporting stool is absorbed by the bottom of the main cast-steel frame. This application of the extruding process eliminates the high first cost of hydraulic pumps and/or accumulators, and brings the manufacture of tubes within the means of the smaller makers.

Hydraulic Push and Chain Draw Benches.

The respective claims of the hydraulic push and the chain draw bench have, since the inception of the seamless cold-drawn tube trade formed a basis of controversy to engineers and actual operators. Both have their advantages and disadvantages, but in most factories the reliance of the management is invested in the chain type.

The hydraulic push bench is confined solely to the use of a solid bar mandrel, and has one distinct advantage over the ordinary chain bench inasmuch as the return stroke of the main ram is utilised for the extraction of the bar from the drawn shell. On the chain bench it is necessary to return the drawing bar, with the tube still on it, to the original starting position, where they are swung round end for end. The back end of the drawing bar is then put through a stripping plate, and connected to the carriage, which is engaged in the endless chain of the bench providing the power for its extraction from the shell. It is then again necessary to return the drawing bar to the die-plate end of the bench, and reverse end for end before the bench is again engaged in an actual drawing operation, making four motions, as against the two of the hydraulic bench. Again, in the operation of the chain bench there is at times difficulty in threading the shell on to the drawing bar, a phase which, in the case of the push bench, is assisted by the forward stroke of the main ram. On the other hand, the chain bench may be utilised for either bar or mandrel (plug) drawing, and where the latter method is adopted the difference in cost of the comparatively short plugs compared with that of the long bars is obvious.

Many attempts have been made to solve the necessary unproductive handling when bar drawing is done on a chain bench, and at Fig. 7 the author introduces a scheme already in practice on small diameters, and which is at least practical. It consists of two benches, arranged in close proximity to one another and placed back to back. The drawing operation having been completed on the one bench, the tube and bar is transferred to the adjacent bench, on which it will be noted the chain traverses in the opposite direction, and on which the bar is extracted. As both benches, when employed for large diameters, are equipped for plug drawing, their employment on such work, when not required for bar drawing, eliminates the responsible foreman from having idle plant on his hand. It is the author's opinion that such an arrangement, under skilled direction, would add considerably to a drawing mill's output. He would also advocate, in the majority of cases, the installation of variable speed motors to each bench engaged in the first or breaking-down passes.

Suggested Methods of Reducing Drawing Costs.

To reduce the necessity of continual annealing and pickling in the course of tube manufacture has always been the aim of the manufacturer, and with no further comment than that the author has on occasions given tubes three and more passes without intermediate annealing and pickling, he attaches an American recipe which may interest readers and enable them to experiment with same.

AMERICAN DRAWING PASTE.

8 sacks of flour. ¾ barrel of tallow.

Mix flour into a thin paste with water and boil until thoroughly mixed, then add tallow.

Boil flour and water in a circular tank in which a small tube coil is installed. Mix with wooden paddle. When thoroughly mixed, put paste into a vat, such as is commonly used for pickling, and add tallow. Keep in liquid state by passing steam through coil. Add daily one sack of flour and one-fifth barrel of tallow.

In concluding this review, it is a pleasure to pay tribute to the progressive investigations of the British Non-Ferrous Metals Research Association in general, particularly to the section investigating under the chairmanship of Mr. A. J. G. Smout, in the Technical Sub-Committee of the Brass and Copper Industry.

The author desires to express his thanks and appreciation to Messrs. Taylor and Challen, Ltd., of Birmingham, and also to Messrs. W. H. A. Robertson and Co., Ltd., Bedford, for collaboration in the preparation of illustrations. The latter are manufacturers of the "Evans" rotary piercing machines, described in previous issues of METALLURGIA.

A Large Gear Wheel Blank.

The illustration below shows one of the largest gear wheel blanks to be cast in one piece. It has been cast at the Cammell Grimesthorpe Foundry of English Steel Corporation, Ltd., to the order of David Brown and Sons, Ltd., of Huddersfield. The casting is 13 *ft.* 8 *in. diameter with a* 40*-in. face; it has nine arms and* 18 *ribs equally spaced, the cast weight being* 27½ *tons.*

Symposium on Cast Iron.

THE presentation and publication of the Symposium on Cast Iron was sponsored jointly by the American Foundrymen's Association and the American Society for Testing Materials to provide concise authoritative data on the composition, metallurgy, properties and applications of the many grades of cast iron now available. The compilation and correlation of the material was directed by an advisory committee consisting of outstanding technologists in the industry appointed by the two societies. This method of preparation ensures an authoritativeness not otherwise possible. The material, as published, is presented under seven broad divisions, including metallurgy, properties, classification, and specifications, heat-treatment, white and chilled irons, and welding.

The section on metallurgy sets forth the effects of the normal elements in cast iron, structural components, general influence of mass and thermal history in structural make-up and alloy additions which have such an important part in varying the properties of cast iron. The chapter on properties should prove especially valuable to the engineering profession. Valuable data from many sources are concisely given with other hitherto unpublished material. The various physical constants and mechanical properties are detailed, and there are data on creep, damping capacity, effects of elevated temperatures, machineability and wear, corrosion and heat resistance.

The group in charge of publishing the symposium have presented much of the data in concise form, though the use of many charts and tables and many appropriate photographs help to interpret the information given. Obtainable from the A.S.T.M., 260, S. Broad Street, Philadelphia, Pa.; or from the A.F.A., 222, W. Adams Street, Chicago, Ill., at $1·00 per copy in paper; $1·25 cloth.

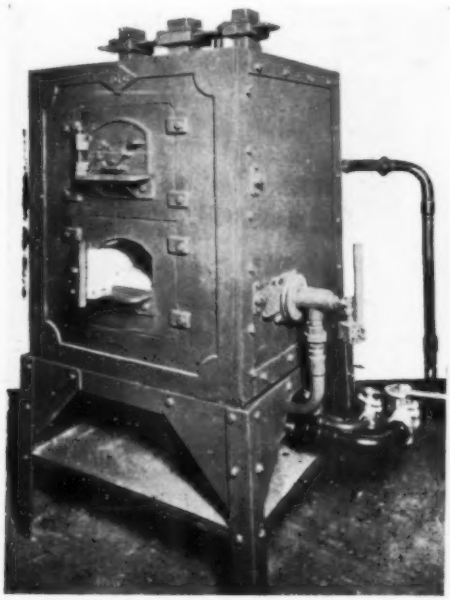
The British Industries Fair

In this survey it is only possible to deal very briefly with some outstanding exhibits that have a bearing upon ferrous and non-ferrous metal production, in semi-finished and finished forms, together with developments and equipment employed in their production.

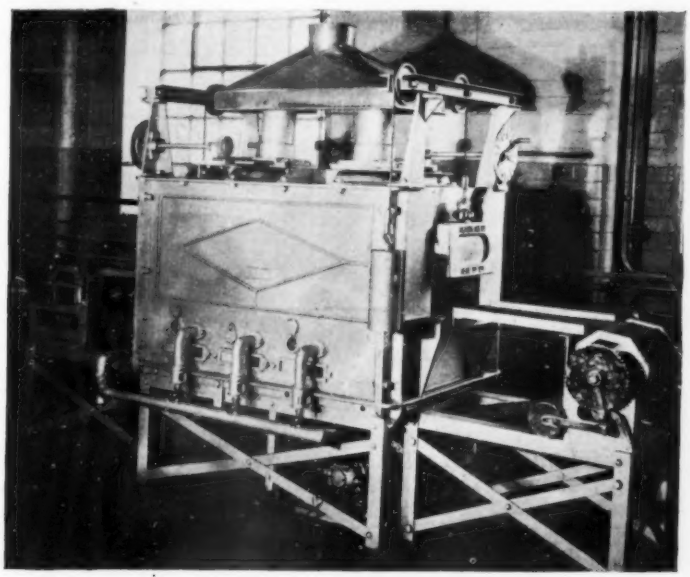
THE British Industries Fair, which opened officially at Olympia and White City, London, and Castle Bromwich, on February 19, and remains open until March 2, is organised by the Department of Overseas Trade, and therefore is a national effort to display the industrial capacity and resources of British industry. Commenced in a comparatively small way, it has grown in dimensions and importance each succeeding year, and this year there are definite indications that it will be more impressive than ever. Each section shows considerable increases both in the area covered and in the number of firms exhibiting. With the gradual growth of this annual Fair the question may well arise : what are the limits in area and number of exhibitors beyond which it would cease to have its proper value as a means of bringing together buyers and manufacturers ? Even now many industrialists are of the opinion that the Exhibition is too colossal to fulfil its objective as thoroughly as it should. There are, however, many advantages offered by the method adopted, because visitors will find it difficult to resist being impressed by the tremendous variety of products available of British manufacture and the system of dividing the exhibits into sections enable those whose interests are concerned with specific types of products to concentrate within a relatively small area.

The Fair provides an excellent means of displaying to potential buyers the enormous range of products manufactured in the British Empire, but in addition it indicates the efforts made to develop new industries and products and to improve their quality and finish. Visitors can visualise the work behind the products which have involved the use of modern machinery and improved technique, and has necessitated close collaboration between research workers and manufacturers. Each succeeding Fair constitutes a new drive for world trade, this one is no exception, and a careful examination of the exhibits by potential buyers will show that the products of British industry, in regard to quality, workmanship, and cost are not exceeded by any other country.

It would obviously be impossible to survey the exhibits of the various sections of this Exhibition within the comparatively small space at our disposal, we shall therefore confine ourselves to those exhibits that have a direct bearing on ferrous and non-ferrous metal production, in semi-finished and finished forms, together with developments in plant and equipment used in various manufacturing operations. The object being to direct the attention of readers to outstanding exhibits within our field, and to assist them to use the time at their disposal in a profitable manner.



Designed by the Sheffield Gas Co. embodying a recently patented process.



Conveyer furnace equipped with nichrome woven wire belt by Incandescent Heat Co. Ltd.

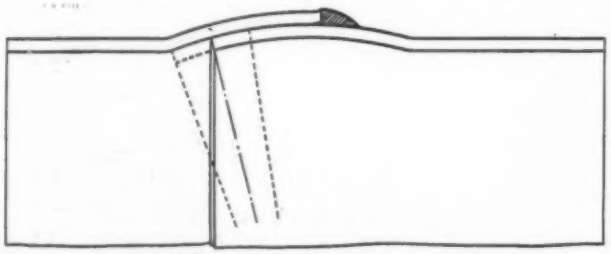
Iron and Steel Manufactures.

Considerable progress has been made in the iron and steel industries during the past year. Attention has been directed not so much to the development of new alloys, but to improved quality and standardisation of existing alloys. With this object plants have been modified or entireiy reconstructed, and with improved technique in manufacture it has not only been possible to improve quality, but in many cases production costs have been reduced. The progress that has been effected has only been possible by close co-operation between research and manufacturing departments. Although a year is really a short time for developments to become effective, the discerning visitor to the metallurgical section at Castle Bromwich will note many improvements, particularly in heat-resisting irons and steels, while developments will also be noted in corrosion-resisting steels.

In the manufacture of pig iron, whether forge or foundry grade, more careful attention is given to analyses, and for foundry use it is noticeable that these are available with phosphorus or silicon contents controlled, a very valuable advantage to the ironfounder who is concerned about the physical properties of the castings he produces. Apart from

a fairly wide range of all-mine pig irons available, a number of refined and alloy pig irons will be worthy of inspection. Foundrymen will be interested in the "Workington" and "Uco" all-mine pig irons of the United Steel Companies, Ltd., particularly to the fact that they are sold to analysis; they should also make a point of seeing the display of Stewarts and Lloyds and the Staveley Coal and Iron Co., Ltd. A conspicuous item of the former firm is a series of examples of pig iron covering the normal requirements of foundries and steelworks, together with a working model illustrating the elasticity of the pig iron.

Probably one of the most important applications of foundry pig iron is in connection with cast-iron pipe mains upon which a good deal of thought has been concentrated during recent years. It is important that pipe mains should withstand vibration under the worst possible conditions to which it may be subjected, and visitors will be impressed by the Stanton-Wilson self-adjusting joint, which is a striking feature of the display of the Stanton Ironworks Co., Ltd. Two Stanton-Delavand spun iron pipes, coupled with the Stanton-Wilson joint, are supported at their outer ends by pivots and at the centre by springs. An electrically-operated vibrator is attached to the centre of the pipes, which are thereby rapidly vibrated. A pressure of 50 lb. per sq. in. air is maintained within the pipes, and is indicated by gauges attached. The object of this test



Spherical welded pipe joint which allows a deflection of 5° when laying.

is to show that the self-adjusting joint will enable cast-iron mains to resist the severest effects of traffic vibration, which is an increasing source of danger to rigidly-jointed mains.

Of special interest is an 18-ft. Stanton-Delavand spun iron pipe, while for the first time a new 3-in. diameter Delavand spun iron pipe is exhibited. This pipe is ¼ in. thick, weighs 1 cwt. per 12-ft. length, and is being sold at the greatly reduced price of 2s. 1½d. per yard, f.o.t. from the manufacturers' works. In addition, a full range of Stanton-Delavand spun iron pipes, in 9 ft., 12 ft., 15 ft., and 18 ft. lengths, will be exhibited.

Sand-spun pipes up to 16 ft. long, in British and metric standards, are exhibited by the Staveley Coal and Iron Co., Ltd. The wide range displayed includes spigot and socket types, turned and bored types, and with flexible joints. Vertically cast iron pipes will also form part of this exhibit. Tubes and fittings for practically every purpose are on view on the stand of Stewarts and Lloyds; in addition, a wide variety of joints are displayed, notable of these is Stewarts' spherical welded joint, which is of special interest for gas or air mains. This joint is constructed so as to allow a deflection of 5° during laying, which enables most curves to be negotiated without the use of bends.

Those who have given a thought to special road surfaces for exceptionally heavy wear and tear will be interested in the floor of the stand of the Stanton Ironworks Co., Ltd. This is paved with cast-iron road sections of the type which this company have supplied for the 3-mile stretch of iron road in the Mersey Tunnel. Diamond-shaped studs on the upper faces of these sections ensure that the surface will remain non-skid in all weathers, and it is noteworthy that these studs are hardened in manufacture, which greatly increases their resistance to wear.

Increasing attention is being directed to the selection of materials used in the production of malleable iron castings, in the melting of the metal and the subsequent treatment of the castings; the object being to achieve control of the quality of products on scientific lines. This is being forced upon the malleable cast-iron industry by the development and keen competition of iron and steel castings. Despite competition, however, malleabe iron castings are being applied in increasing quantities, which is due, in no small measure, to the progressive policies adopted by many firms represented, which include Thomas L. Hale (Tipton), Ltd., Leys Malleable Castings Co., Ltd., Coventry Malleable and Aluminium, Ltd., and others whose exhibits should be examined. Both whiteheart and blackheart castings will be on view.

Carbon and Alloy Steels.

The range of steels now available is very great, from the low-carbon structural steels to the high-alloy types. In each grade efforts have been made to improve quality rather than in the development of new products. It is noteworthy, however, that lacquered steel strip is exhibited by United Steel Companies, Ltd. This strip can be blanked, stamped, and perforated without the lacquer chipping or flaking, and its application covers a wide field. This material is new to this country, and is available in a range of fifty standard colours with glossy or matt finish.

Railway connecting rod in "Tormol" nickel-chrome molybdenum steel.

Wimet-tipped inserted blade milling cutter.

With the need for low production costs, deep stamping steels have won a special field of usefulness and laboratory control of quality in the manufacture of these steels ensures that uniformity and freedom from defects are maintained at their highest possible value. The manufacture of these steels has made rapid progress during the last few years, and so satisfactory are the results that many parts, formerly machined from the solid, are now made from strip. The steel used is the mildest available, but modifications in composition are necessary to cover the field of applications adequately. British Rolling Mills, Ltd., manufacture two steels of different types and pressings, which will be exhibited. Reliable cold-worked steels in strip and wire form are also exhibited by United Steel Companies, Ltd., Thos. Firth and John Brown, Ltd., Sanderson Bros. and Newbould, Ltd., and a number of other firms.

Case-hardening Steels.—These steels are used for such widely varying purposes that special types have been developed to meet special needs. Thus, there is a wide range between the free-cutting steels and the alloy steels,

possessing very high core strength. The technique of manufacture is developed with a view to eliminating impurities, so that the steels may be free from seams, hair lines, and other defects. Several firms give special attention to the manufacture of these steels, and those interested so see the various types displayed by British Rolling Mills, Ltd., and certainly should not miss examining the gears exhibited by United Steel Companies, Ltd., which illustrate their "Hicore 90" alloy steel. As the name of this steel indicates, the core strength is 90 tons per sq. in., which permits a thinner, well-supported case, and minimises chipping trouble.

Alloy and Special Steels.—The display of rolled sections, plates, sheet, tubes, and wire, in ordinary carbon steel, in a variety of shapes and sizes, will show manufacturers are meeting the needs of users; but the increasing application of alloy and special steels will probably attract most attention, particularly some of the stainless steels, with their remarkable finish. Amongst the exhibitors of the latter, attention should be given to the display of Thos. Firth and John Brown, Ltd., United Steel Companies, Ltd., and Darwins, Ltd. These are shown in the form of sheets, castings, and wire, both polished and unpolished. Various qualities of nickel-chrome heat and acid-resisting steels suitable for numerous applications, will, in some cases, be demonstrated under actual working conditions.

The application of alloy steels to general engineering is gradually increasing with greater knowledge of the properties of these steels, and improvements in their manipulation. Thus, it is recognised that a nickel-chrome-molybdenum steel, such as "Tormol," manufactured by United Steel Companies, Ltd., is much lighter in weight for a given strength in comparison with a carbon steel, and this enables considerable savings in the weight of reciprocating parts. Interesting data showing comparative weights of parts made from carbon and alloy steels are given on the stand of United Steel Companies.

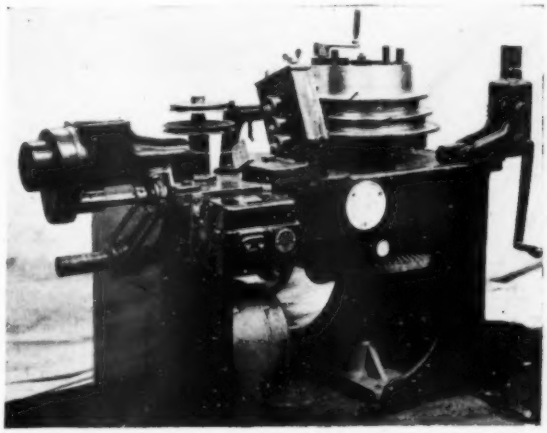
Tool Steels.—Those in search of tool steels should not overlook the various grades manufactured by Darwins, Ltd. Two of these include the well-known qualities of 18 × 14% tungsten high-speed steel, but two steels each containing cobalt are manufactured specially for machining very hard materials. A wide range is also shown by Sanderson Bros and Newbould, Ltd., the applications of which are shown in the various types of tools produced by this Company. Of special interest is their well-known "Sanbold" segmental saw for the rapid cutting of cold metals, whilst machine knives, files, and rasps, twist drills, and milling cutters are a few of the special tool exhibits.

Darwins, Ltd., show various press tool steels; for quantity production they specially recommend "Neor" and "Cobaltcrom" qualities. This latter steel is also recommended for shear blades because of the long life and service it gives. It is not possible to refer to all the tool steels which are exhibited, but in each instance so much care is now exercised in their manufacture that claims are made for consistency in quality. This factor is of the utmost importance to users, as it controls the degree of success possible for any material.

Alloying Elements.—The application of alloying elements in steels suitable for many engineering purposes is demonstrated by the exhibits of High Speed Steel Alloys, Ltd. These have been secured through the co-operation of well-known steel and engineering firms employing the pure metals and ferro-alloys supplied by this company. A full range of alloys of tungsten, vanadium, molybdenum, chromium, and other elements used in special steels, is on view, together with a representative range of fine chemicals in grades suitable for commercial and laboratory uses. Engineering designers and others who are interested in alloy steels are able to see exactly what advantages can be obtained by the adoption of such steels in comparison with carbon steels. An interesting illustration at the present time is the employment of molybdenum steels for securing a substantial reduction in weight as applicable to the construction of heavy transport vehicles in which "pay loads" have assumed extraordinary importance under the new Road Traffic Acts. Finished and semi-finished engineering parts are on view, also tensile, torsional, and impact tests are shown of the various grades of alloy steels in general use.

Other Cutting Alloys.—In addition to various tool steels, various types of cutting alloys will be exhibited, notable of these being "Stellite" and "Wimet." The former is a cobalt-chromium-tungsten carbide cutting alloy, which is manufactured by Deloro Smelting and Refining Co., Ltd. It is available in many grades to meet special requirements. Attention is directed particularly to a new grade heavy duty cutting alloy applied to stellite-tipped tools, solid tool bits, and milling cutter blades, which will be exhibited. Further applications of stellite will be duly noted. These include tipped lathe centres, tipped work rests for centreless grinder machines, stellited conveyer screws, skidder bars for conveyers, and coal picks. Stellite valve seats have also been standardised by leading makers of commercial vehicles, and the wide range of applications for this material will prove most interesting.

Wimet brand tool metal will be shown by A. C. Wickman, Ltd. This is available in five grades, which are manufactured for dealing with specific materials. Various types of reamers are on view, the development of which has made great strides during the past year. The latest design of the Wickman "Wimet"-tipped inserted blade milling cutter is much in evidence. The new design includes extremely strong and rigid body, and maximum support is given to the blades besides providing for adequate chip clearance. This exhibit includes various types of standard Wimet-tipped tools, Spedia lapping wheels, Spedia hand-lap and grinding wheels. Spedia lapping wheels are used for the final lapping of Wimet brand cutting tools, gauges, etc., and are claimed to be the only known free-cutting wheels which will give a fine finish to the cutting edge. The various applications of this cutting material will be projected on the stand from a film.



Wire-drawing machine exhibited by the Whitecross Co. Ltd.

Steel Tube.

The use of weldless steel tube is increasing, and so many applications are demonstrated that it would be impossible to enumerate them here, but examples shown by Tubes, Ltd., are applicable to a great number of manufacturing industries. This exhibit includes cold-drawn seamless steel tubes in all sizes from ¼ in. to 15 in. internal diameter, in both carbon and alloy steels. Amongst the special features are cold-drawn tubes for Admiralty boilers, locomotive boilers, and also cold-drawn steampipes. Special corrosion-resisting "Resisters" tubes, alloy steel tubes for the chemical industries, and oil-cracking tubes in straight carbon and alloy steels, make an impressive display, while the motor industry are catered for by tapered and swaged

tubes, bush tubing, superheater and other tubes. The modern applications of metal tubes are nearly endless, and their range of utility is best understood by a visit to the Exhibition, and this should include the exhibits of the Britannia Tube Co., Ltd., who show a wide variety of cold-drawn steel channels and tubular sections. Various classes of seamless steel tubing are exhibited by Reynolds Tube Co., Ltd. These are in various grades of steel, ranging from low carbon to alloy qualities, and particular prominence is given to tube manipulation and examples of the application of manipulated tubes to various industries are shown.

Wire.

Of the many exhibits of wire, mention may be made of that manufactured and shown by the Whitecross Co., Ltd. This exhibit conveys the wide range of manufacture, which in addition to wire netting, barbed and fencing wire, includes many specialities. Attention is directed to the well-known "Silflex" brand galvanised wire, which will not flake or peel even when wrapped round its own diameter. The demonstration of the actual drawing of wire is both interesting and informative, and should be witnessed if time permits. The evolution of wire rope from the raw material through the various stages of manufacture to the finished condition will prove of special interest. The majority of firms displaying wire in its various forms show it in bulk form and without reference to the methods of manufacture. An interesting wire drawing machine is exhibited by Sir James Farmer Norton & Co., Ltd.

Rust Prevention.

Many methods for protecting the surfaces of iron and steel articles are in use. The importance of reducing the effect of rust has long been recognised, and the "Sheradising" process shown by Zinc Alloy Rust Proofing Co., Ltd., is well known. This process consists in heat-treating the articles in contact with zinc dust in such a way that an iron-zinc alloy is formed on the surfaces, which provides effective protection. Not the least important of the rust-proofing processes are those known as Parkerising and Bonderising, each of which has its special advantages For Parkerising the parts are immersed in a solution consisting of Parks powder and boiling water. The surfaces of the parts are converted to an insoluble phosphate, which is impervious to rust under ordinary atmospheric conditions. The process is completed by the application of a finish or treated with paint, enamel, or lacquer. Bonderising was developed as a base for paint, enamel, or lacquer, and is a chemical priming operation which converts the surface of the steel to a practically non-metallic coating which is quite opaque, and which seals the pores of the metal. In addition, the surfaces are chemically clean and ready for enamelling, etc. The parts to be treated are immersed in a solution of Bonderite powder and boiling water for 5 to 10 mins.

Miniature plants in actual operation are running on the stand of the Pyrene Co., Ltd., demonstrating the two latter processes. The protection afforded by hot galvanising and dip tinning is well known; these methods, however, are not usually applicable to large structures. The value of these metallic coatings is appreciated, and a method is now available which can be applied to structures that cannot be conveniently treated by the methods mentioned. This is by metal spraying, from a tool known as a "pistol." British Oxygen Co., Ltd., are demonstrating with this method.

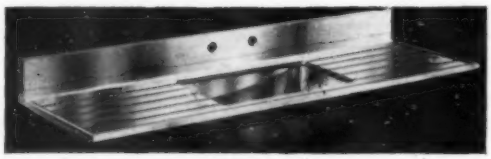
Non-Ferrous Metals.

A feature of 1933 was the increasing use of pure nickel for coinage, new nickel coins having been issued during the past few months by France, Germany, and Japan, and exhibits by Henry Wiggin and Co., Ltd., illustrate the steps in the manufacture of finished coins from pure nickel strip. Pure nickel also finds wide employment in the food industries, some examples of which are on view.

Since the last Exhibition, the first pieces of equipment to be made in this country of two new nickel-containing materials have been put into service. One of these materials is nickel-clad steel, a composite product consisting of nickel rolled on to steel at a high temperature to give a perfect bond. It possesses many of the valuable properties of pure nickel, and offers a solution to many problems where thick section, strength, and resistance to corrosion are required at moderate initial cost. The other new material is the nickel-chromium alloy called "Inconel", which is characterised by excellent corrosion-resisting and mechanical properties, and can be readily welded.

In view of the growing interest in nickel steel for boilers, particular attention should be drawn to an exhibit of nickel steel locomotive boiler plate, which shows the surface obtainable. Tensile, bend, and torsion test-pieces, illustrating the quality of the material, are shown by the Mond Nickel Co., Ltd.

The uses of Monel metal increase in scope each year, and this well-known nickel-copper alloy has recently been introduced to the household field, where its silvery lustre, rustless surface, and extreme durability combine to make it an ideal material for sinks and drainboards, table tops, and shelving. On the stand will be exhibited a Monel



Monel metal sink; a recent introduction in the household field.

metal sink, having a single bowl and double drainboard, one of the range of standard models which have just been put on the market. This will be exhibited in a model kitchen, which will also include electrical apparatus, such as a water-boiler, cooker, kettle, etc., in which Wiggin electrical resistance alloys are employed.

A new development of considerable importance is the introduction to this country of "Inconel." Originally developed for use in the dairy, where it has proved eminently suitable for handling milk, the usefulness of this nickel-chromium alloy in other branches of the food industry is becoming quickly appreciated. Sheet and tube samples in this material are displayed by Henry Wiggin & Co., Ltd.

With the reorganisation of the "heavy" section of the Fair at Castle Bromwich, the non-ferrous exhibits are now located in the engineering section. As before the exhibits are sectionalised and the space available to I.C.I. (Metals), Ltd., is devoted to strip and sheet, tubes, rod, and the extruded sections, plates, and wire. The new electric mills installed at the works of this firm have made possible the production of long continuous lengths of strip, weighing nearly half a ton each, which is one of the chief features. Another important feature is the new "Resisco" zinc-free tube, which has been introduced with marked success for condenser work. The display will attract considerable attention, especially as practical demonstrations are again arranged—one of the most interesting dealing with the properties of a series of new copper alloys discovered in the Research Laboratories of the company. Another demonstration shows the actual welding of copper by oxy-acetylene. Cinematograph films show the processes of manufacture of many of the products.

Of more than usual interest are the exhibits of McKechnie Brothers, Ltd., which include this firm's well-known "Tank" brand and "MKB" extruded brass, bronze, and white-metal rods and sections, solid hot brass, bronze, and white-metal stampings, chill-cast phosphor bronze, and gunmetal bars for bushes and bearings. The exhibits include phosphor bronze, gunmetal, manganese copper, naval brass, and nickel-silver ingots; manganese bronze, granulated nickel, and anti-friction metals. A wide range of samples of extruded sections are on view, which give an

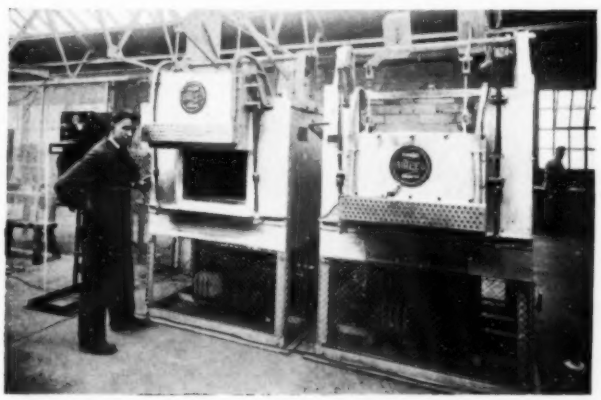
excellent idea of the variety of sections that can be produced by the extrusion process. These sections are produced so close to required dimensions that machining is cut down to an absolute minimum, and in many cases is entirely eliminated.

Serck Tubes, Ltd., exhibit a full range of non-ferrous tubes in brass, copper, aluminium, gilding metal, bronze, zinc, Admiralty gunmetal, etc., making a special feature of super quality 60/40 cupro nickel, by the use of which the corrosion of circulating heating and cooling plants is reduced to a minimum, together with a special display of service copper as used by the plumbing trade generally, and supplied in a temper suitable for cone-joint fittings and manipulation without further heat-treatment. This is guaranteed made from virgin metal of a purity of 99·9%. In addition, a comprehensive range of shapes and sections for different trades and industries, radiator tubing of light guage, having a wall thickness of 0·005 in. for car and aero use, and as supplied for the radiator water cooling of Captain Malcolm Campbell's *Blue Bird*, Napier Campbell cars, and also the Schneider Trophy aeroplanes.

Another interesting exhibit covering a wide range is that of Earle, Bourne and Co., Ltd. These include cold-rolled brass of various compositions, copper and aluminium alloys. Attention is directed particularly to the "Sechlin" brand aluminium alloy, which has a specific gravity of 2·8, and in the strip form has a tensile strength of 25 tons per sq. in., with an elongation of not less than 8%. It is available in the form of sheet, strip, and tube. In addition, there is a display of solid drawn brass and copper tubes for locomotives, condensers, sugar refineries, engineering, shipbuilding, refrigerators, etc.

An alloy which can be varied so that its tensile strength covers a range from 24 to 87 tons per sq. in., without any alteration in the composition of the metal, is of unusual interest. It is known as "Tungum" alloy, and is exhibited in a variety of commercial forms by the Tungum Sales Co., Ltd. It has a 22-carat golden colour, and may be produced as soft as copper or as hard as steel.

Aluminium and its Alloys.—Some indication of the increasing application of aluminium and its alloys is presented by the wide range of exhibits. Some of the more

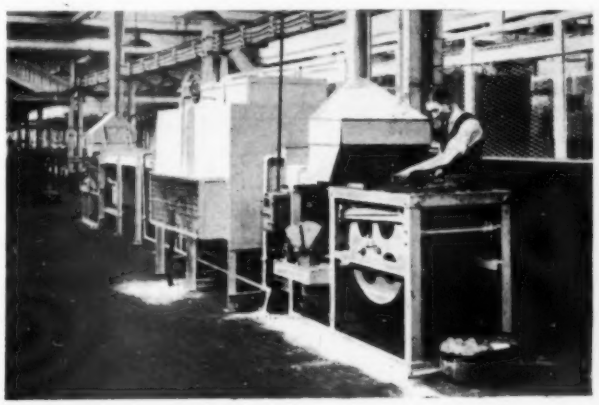


Two Birlec R.P. type box furnaces for general heat-treatment, with hook type elements.

conspicuous examples are shown by the London Aluminium Co., Ltd. Apart from applications in the food industries, which are making increasing use of aluminium, this company manufacture such well-known brands of aluminium alloy as "Duralumin," in various grades, "Wilmil," "Birmabright," and M.G. 7, and samples exemplifying these products. Included among the latter are hot pressings, in which light alloys are now playing an important part.

An exhibit of special interest to engineers concerned in the construction of high-speed Diesel engines is a range of aluminium alloy pistons exhibited by the Birmingham Aluminium Casting (1903) Co., Ltd. These vary from 5 in. to 12 in. diameter, and are specially designed and produced to work under the arduous conditions obtaining in such engines. A wide range of "Birmal" castings produced by the pressure die, gravity die and sand-casting processes cover exhibits varying in size from the crank-chambers of high-speed Diesel engines to minute pinions and counter-wheels for meters and other counting machines.

Cast and wrought forms of "Birmabright" corrosion-resisting aluminium alloy are displayed by Birmabright, Ltd. These include rolled sheet and strip, extruded bars, sections, and tubing of various shapes, drawn wire, etc. A number of special examples of fabricated work are also shown, such as a 10 ft. 6 in. rowing dinghy and a ship's side scuttle representing marine applications, a 4 ft. square-cast spandrel, a balustrade panel and grille as utilised in architectural work; a showcase for shop and exhibition use, as well as samples of door furniture and window fittings, perforated plate, wire fastenings, pressings, stamp-



Birlec continuous belt-conveyer type bright annealing furnace.

ings, forgings, rivets, bolts and nuts, metal thread and wood screws and castings produced for several purposes. Different surface finishes that can be obtained are also being demonstrated.

Components that are manufactured for some of the largest firms in the engineering and allied trades are shown by Aluminium Alloy Die-Castings, Ltd. The accuracy obtained by die-casting these components creates a demand which is continually growing, and these exhibits will direct attention to the economies and other advantages of making use of die-castings when the quantities required warrant the making of dies.

Melting and Heat-Treatment Furnaces.

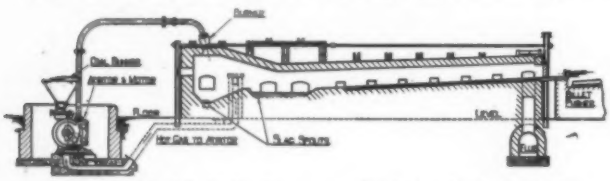
A joint industrial gas exhibit was given a trial on a comparatively small scale last year, and this year it is arranged on a more comprehensive plant. It has been arranged by the British Commercial Gas Association in co-operation with the Gas Light and Coke Co., Ltd., London, the City of Birmingham Gas Department, the Sheffield Gas Company, and the Newcastle-on-Tyne and Gateshead Gas Company, which undertakings have very large industrial consumptions within their area of supply.

This exhibit is intended to fulfil several purposes. It will keep before the manufacturer the fact that gas is being used in rapidly increasing quantities as a fuel in industry, also bring to his notice the improvements in the design of gas-heated furnaces and appliances which are continually taking place. Among the exhibits is an entirely new design of gas-fired muffle furnace suitable for operation at all temperatures up to and including 1,000° C. It is built to Gas Light and Coke Co. design by Selas Gas and Engineering Co., Ltd. The smaller sizes are suitable for numerous laboratory and experimental uses, such as testing of materials at various temperatures, assaying, metal and other heat-treatments, enamel work, pottery and glass firing, many kinds of analytical work, and a wide variety

of other purposes. The larger sizes are for actual productive work, as well as experiments and tests on a bigger scale. An interesting conveyer furnace is exhibited. This is designed and constructed by Incandescent Heat Co. Ltd. It is equipped with nichrome woven wire belt, which is driven from small electric motor through a reduction gear: it is fired by a series of patent incandescent gas-fired burners, and the temperature can be very readily controlled between very critical limits. The type of furnace is suitable for the heat-treatment of metal parts as used in the telephones, radio, and electrical trades. Its construction is such that it can very readily be equipped with preheating and cooling sections, and also presents an opportunity of handling small numbers of articles by a continuous method.

Designed for the melting of metals such as brass, copper, gunmetal, etc., is a small crucible furnace by British Furnaces, Ltd. It has a cylindrical combustion chamber into which the crucible fits, and is heated by a single flame firing tangentially into this chamber. The flame is generated by low-pressure gas and blast air, or, if temperatures over 1,400° C. are required, by high-pressure air regulated by British Furnaces type automatic proportioning device. The temperature is therefore adjusted by means of the air supply only, the pressure gauge serving to indicate the rate of heat input.

In operation this furnace gives very quick heating-up and has a high maximum working temperature (about



Arrangement of "Atritor" process of using pulverised fuel for a reheating furnace.

1,650° C.); moreover, the control of the air-gas proportioning makes it extremely simple and economical. A standard type of furnace is shown by Birmingham Gas Depot. It has a hearth area approximately 18 in. × 9 in. × 9 in., and is of comparatively simple construction. Special attention has been paid to the burner equipment, and this is standard, the inspirator and burner nozzles being made by Messrs. British Furnaces, Ltd., incorporating their proportioning device and single tap control.

The heating of billets of varying sizes, from ½ in. to 2 in. diameter, or even larger in some cases, for pressing between dies, has developed within the last few years to an industry of considerable magnitude. Gas furnaces are used for the heating of these billets. The general furnace is direct-fired, fed with gas at ordinary pressure, and air under pressure of about 1 lb. per sq. in. A furnace is exhibited which is representative of the types used in this particular industry, and which embodies one or two special features of control and methods of billet feeding which have been found of value.

The use of salts for the heat-treatment of steel, both for hardening and tempering operations, is continually extending. Two furnaces represent the process, one made by Mr. John F. Askam, the other by Messrs. Brayshaw Furnaces and Tools, Ltd., each embodying a special arrangement of handling which has been designed by the firm concerned.

The Newcastle-on-Tyne and Gateshead Gas Company is carrying out practical heat-treatment on work which has to be put immediately into general use, demonstrating the value of gas fuel in the heat-treatment operations.

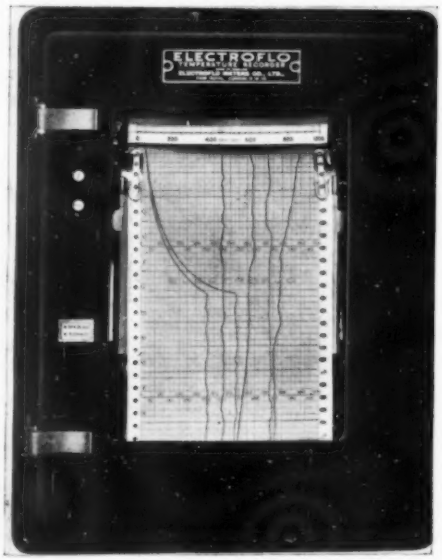
The Sheffield Gas Company is exhibiting three types of gas-fired furnaces which have a very wide field of application in the steel trades. Two of the furnaces are specially designed for the successful heat-treatment of high-speed steel tools, and are essentially high-temperature furnaces. The third furnace is a gas-fired annealing or low-temperature heat-treatment furnace, and is designed to carry out annealing processes without the use of containers, and at the same time to prevent damage to the surface of the material being heated. All these furnaces are designed to illustrate the application of the recently patented process of the Sheffield Gas Company for the heat-treatment of steel without the formation of scale or decarburisation.

The various furnaces in this display are fitted with automatic control and pyrometer apparatus by the Cambridge Instrument Co., Electroflo Meters, Ltd., Elliott Bros., Ltd., and the Foster Instrument Co.

Among the electric furnaces, probably chief interest concerns the continuous belt-conveyer type bright annealing furnace exhibited by Birmingham Electric Furnaces, Ltd. The furnace shown is a demonstration model, but it represents a type of equipment which is being very rapidly adopted for annealing and other processes, in which the prevention of the oxidation of the work is of importance. It is also very successfully applicable to bright copper brazing, bright silver soldering, and other such work in which it is essential to maintain the surfaces to be joined in a clean condition during the passage of the work through the furnace.

The equipment comprises a heating chamber and a water-jacketed cooling chamber, the two being maintained full of a gas or mixture of gases having a neutral or slightly reducing action on the work being treated. These gases are generated by separate equipment, and many different types of apparatus are available for this purpose, according to the nature of the material under consideration.

Conspicuous among these exhibits is a large, rectangular, batch-type furnace for annealing, normalising, carburising, and general heat-treatment work, which has many important technical features. Noteworthy of these is the patented method employed for mounting the heating elements, whereby the latter are maintained out of contact with the refractory lining of the chamber. In this way local "hot spots," due to shielding of the heating elements by the refractory, are prevented, and any possibility of chemical interaction being set up between the elements and fire-



Two-point recording pyrometer for the hot-blast main and downcomer temperatures, or for stove gas and air temperatures in blast-furnace plant.

brick is avoided even under the worst conditions of operation.

In addition to the foregoing furnaces, two small tool-room models, intended respectively for the hardening of high-speed steel and for the secondary hardening of high-speed steel, the tempering of carbon steel, etc., are shown. The former furnace employs non-metallic heating elements, and is capable of operating at temperatures up to 1,400° C. Its outstanding feature is the provision of a special atmosphere control arrangement—known as the "Certain-Curtain" system,—which is successful in eliminating com-

pletely the scaling or decarburising of the surface of the steel. The secondary hardening or tempering furnace constitutes a new addition to the existing range of " Birlec " forced-air circulation furnaces for low-temperature heat-treatment. The same general principle is employed, the patented centrifugal fan being used to provide the necessary powerful air circulation.

Casehardening is not a subject that gives much scope for originality in exhibition treatment, but the Cassel Cyanich exhibit is of interest. The fact that the case-hardening process is demonstrated promotes this interest, and visitors can have their own metal parts hardened while they wait. A feature of this exhibit is an automatic control Cassel furnace in operation, and there are many examples of casehardened steels for comparison with various alloy steels, which have been heat-treated only.

The use of pulverised fuel in this country has made great progress in the last few years, both in its application to the firing of boilers, and also to metallurgical furnaces for rolling, forging, stamping, and many other purposes, and Alfred Herbert, Ltd., are exhibiting one of their small " Atritor " pulverised fuel plants. Owing to the small space available and the difficulty of handling supplies for a large furnace, their exhibit is confined to two small furnaces, one for the heating of bars for the manufacture of bolts and rivets, and the other for forging purposes.

During recent years very considerable progress has been made in the application of the Atritor system to metallurgical furnaces both of the continuous and the in-and-out type. These are now in use heating ingots, billets, and bars for a variety of purposes, such as stamping, rolling, tube-drawing, and heavy forgings up to 60 tons in weight. Furnaces fired by pulverised coal have also been installed for annealing processes in the manufacture of guns, and substantial economies have been effected by these applications. The Atritor is usually installed on the unit system—that is to say, the machine is fed with raw coal, which it dries, pulverises, and passes direct to the furnace for combustion.

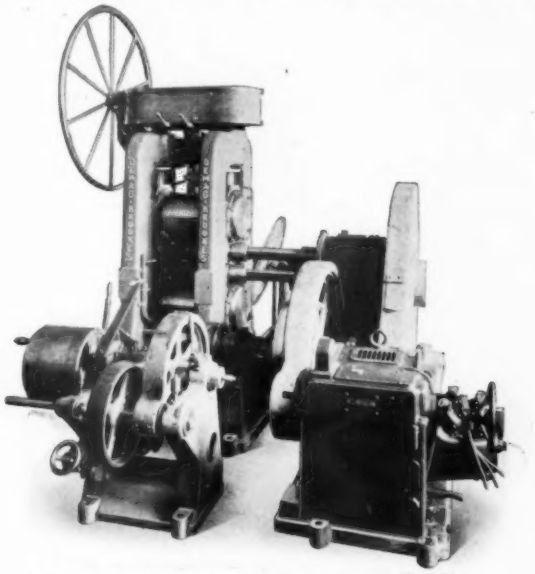
Recording and Indicating Instruments.

The economic advantages of reliable instruments and gauges in connection with various industries are now fully recognised. Among the new instruments exhibited by Cambridge Instrument Co., Ltd., are examples of re-designed mercury-in-steel thermometers, both indicating and recording, large diameter chart recorders for pressure and humidity, new designs of temperature controllers, a portable recorder, and a new CO indicating outfit for measuring small percentages of carbon mom-oxide gas in tunnels and mines.

The principal improvements in the mercury-in-steel thermometers are in the construction of the bulb, the capillary tubing and the Bourdon tube, and in the adaptation of the instruments for mercury-vapour thermometry, enabling them to be used for temperatures up to 700° C. or under certain conditions for occasional temperatures up to 800° C. The new indicating thermometers are fitted in a strong pressed-steel case, which is adapted either for wall mounting or flush mounting on a panel. Three illuminated moving-scale indicators are shown on a panel which represent an important development: two show temperature measurements, and the third CO_2 percentages.

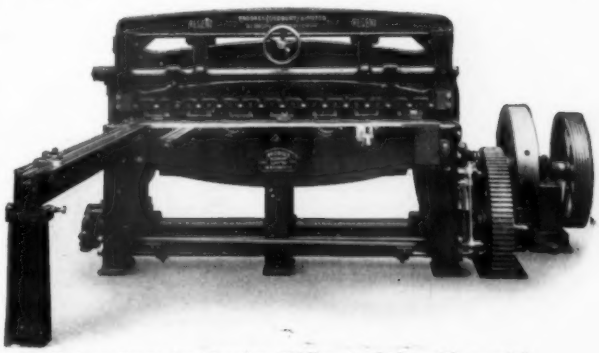
In addition to various electrical temperature-measuring instruments, Foster Instrument Co. is showing several new pieces of apparatus, and is also demonstrating several special applications of their instruments, particularly those applied to steel works' practice.

Automatic temperature regulators for controlling the temperature of electric furnaces, and the temperature and atmosphere of fuel-fired furnaces, etc., gas flow and pressure indicators and recorders, gas analysers, single and multiple suction and pressure gauges, indicating and recording pyrometers, thermometers, etc., are shown by Electroflo Meters Co., Ltd. A novel exhibit is the Electro-flo electrically-operated, distance indicating and signalling system, for application to waterless gasholders. The transmitter is driven by chain and sprocket, and the rotation of the shaft raises and lowers a multi-conductor type of resistance in a fixed mercury well, thereby regulating the conductance of the distantly-located electrical reading instrument, which is calibrated in feet, so that the pointer shows the height of the gasholder at any instant and the corresponding gas volume. In the combined indicating and signalling system the signals are made by means of lamps, and the dangerous positions of which warning is required are indicated by various coloured glasses in the lamp boxes. These signals are operated as the shaft of the transmitter rotates by a cam and plunger mechanism, positioning mercury contactor switches. A Klaxon warning horn is included, the connections to which are adjustable, so that it can be made to sound at any predetermined gasholder height.



" Demag-Brookes " four-high cold strip rolling mill.

Brookes (Oldbury), Ltd., are showing various plant exhibits; noteworthy of these are a four-high cold strip rolling mill and guillotine shears. The former is a " Demag-Brookes " product, built under licence by Brookes. There are many features about this mill which are worthy of the attention of visitors interested.



Guillotine shears by Brookes (Oldbury), Ltd., with special gauging features.

The services of guillotine shears are being increasingly used in the ferrous and non-ferrous industries, and many types of these labour-saving machines are available. Of particular interest is a 6-ft. machine, capable of cutting up to $\frac{3}{16}$ in. thick mild steel. The chief interest lies in the equipment for gauging; this includes a screw-operated back gauge, operated and locked from the front of the machine.

COLOURED ALUMINIUM.

A DEVELOPMENT of considerable importance is dyed metal, samples of which are shown at the British Industries Fair. The metal will be aluminium, and strips of it dyed in a variety of colours and effects will be shown on the dyestuffs stand of Imperial Chemical Industries, Ltd., at Olympia. This development is of great interest owing to the fact that metal has hitherto proved the only material in common use which has resisted all efforts of the dyer. Under the new Gower process, which is operated in this country by Messrs. Alumilite, the Thames Factory, Rainville Road, Hammersmith, aluminium may be permanently dyed in almost any shade or colour.

The actual process is one of extreme simplicity, and is rendered possible by the special properties which aluminium possesses as a metal. Aluminium exposed to the atmosphere under normal conditions forms a transparent superficial film of oxide, which, once formed, acts as an efficient sealing agent against further oxidation, and which is of extreme hardness and remarkably resistant to abrasion. Besides having a protective effect, the film is able to take up and permanently retain particles of colouring matter; certain aluminium compounds possess the property of taking up colloidal particles, which permits of their use as clarifying agents for water, or more particularly as mordants for dyestuffs. Oxide of aluminium has definite mordant properties, so that on simple oxidation the surface of the metal becomes automatically prepared for the dyeing process. The hardness, as well as the colour-absorption properties of aluminium oxide is well exemplified in certain precious stones and minerals; some of the most brilliantly coloured precious stones contain aluminium oxide in large quantity, and corundum, of which ruby and sapphire are coloured varieties, and which is one of the hardest substances known, is almost pure alumina.

The object of any process of preparing the surface of aluminium objects for dyeing must therefore be artificially to increase the degree of oxidation, for the permanence of the dyed surface and its hardness must depend principally on the depth of the oxide film. In the Gower process this is effected by an electrolytic method, in which the aluminium articles to be treated form the anode of an electrolytic cell. Electrolysis results in intensive oxidation of the surface of the aluminium, the porosity, flexibility, and hardness of the anodic film so formed being governed by such factors as the current density and the temperature of the solution. Only dilute sulphuric acid, out of the various acid baths tried, has been proved capable of treating any form of aluminium, whether wrought, cast, or in the form of alloys, and of permitting absolute control of the surface films formed. Dilute sulphuric acid is the cheapest electrolyte conceivable.

The process of oxidation consists of three treatments:—

1. Cleansing and polishing of the aluminium objects.
2. Anode oxidation.
3. Washing of the oxide film.

Polishing is essential before immersion in the electrolyte, since any defect in the surface will be emphasised by the colour subsequently applied. The immersion time, which determines the depth and flexibility of the film, varies from 10 mins. to 1 hour, the voltage being of the order of 10–15, with the bath maintained at 15–20° C. After this treatment, the aluminium presents a silver-white surface, and if it is now simply immersed for a few minutes in a bath containing an organic or a mineral colouring matter, it will take up the colour, just like wool or cotton.

The colour is made proof against abrasion by immersion in a "sealing-bath." Previous to this stage, the oxide film may be looked upon as having a crystalline structure, in which the component crystals are standing on end in a vertical position. The action of the "sealing-bath" is to cause these crystals to lie down one over the other, forming a laminated structure, and thus securely locking the colour into the metal. If this sealing process is carried out before dyeing, an extremely hard silvery surface is formed which will not take up colours; the colour can either be locked out or locked in.

The colouring process enables deep penetration to be effected in a wide variety of colours, which may be either lustrous or matt. Most of the organic colouring matters, such as the anthraquinones and alizarins, may be used, and the finish is much more permanent than that given by lacquering or plating. The colour range extends from jet black and cream to the most delicate pastel shades, and includes the metallic colours—gold, bronze, and copper. All such colours are remarkably sunfast, but where exceptional heat fastness is required mineral colouring matters, such as cobalt salts, are naturally called for. There has recently been developed a series of colour combinations which widely extend the field of application of the "Alumilite" process. This includes combinations such as black and green and gold, and many others, up to ten-colour combinations.

Pure aluminium, as well as all worked-up aluminium alloys (sheets, profiles, rods, tubes, wires) with copper content up to 9% and zinc content up to 14%, can be subjected to treatment by the new process. The uses for coloured oxidised aluminium are seen to be infinite, especially where particular value is attached to freedom from rust and corrosion, durability of the colouring film, beauty, and light weight.

A New High-speed Method of Case-Hardening.

A NEW method has been developed for the heat-treatment and case-hardening of steels for which many advantages are claimed. The method involves the use of a substance which is known as "Durapid," in the form of a liquid, the application of which is by dipping only. After being dipped directly into the bath containing the thin paste, the parts to be treated are put into a muffle furnace without any packing. By this process the parts are coated with the paste, and this coating, which is about $\frac{1}{8}$ in. thick, is readily penetrated by the heat of the furnace.

The principal advantage claimed for this process is the reduction in time necessary in the carburising furnace. Thus, the structure of the core is less liable to be coarse from excessive heating, and is more easily restored during the reheating process. Where the depth of case is comparatively small—say, 0·5 mm.—the reheating for core structure often may be omitted altogether. The shorter heating time also tends to reduce distortion to a minimum, especially where the work is large and heavy and the time in the carburising pots by the usual method is often about 14 hours.

When a number of large parts are packed in a box, which is necessary on account of economy, the box becomes heavy and unwieldy, with the result that the parts are usually left to cool down with the box after it has been removed from the furnace. This comparatively slow cooling through the critical range frequently gives rise to grinding trouble through exfoliation of the case.

A further advantage of the reduced time of heating and cooling is the possibility of running at a higher carburising heat without any serious trouble. For instance, by this process a carburising temperature of 940° C. can be used as safely, it is claimed, as 900–920° C. by the ordinary pack method. This means that a depth of 1 mm. can be obtained in 1 hour to 1¼ hours carburising, to which, of course, must be added the time necessary to bring the work up to 940° C.

It is also worthy of note that by this new process a very gradual transition is obtained between core and case. This is most important, especially where the depth of case is over 1 mm., otherwise troubles due to "flaking" of the case are not uncommon. Each piece is more or less handled separately, and when taken out of the furnace is cooled rapidly with consequent improvement in the structure.

Stresses in Fusion Joints

The application of electric welding to structural work is making rapid progress, but the variety of new forms employed offers numerous fields of inquiry covering a range of problems, and a recent experimental investigation by Professor E. G. Coker, Miss R. Levi, and R. Russell is described in a paper published by the Institution of Mechanical Engineers, of which extracts are given in this article.

CONSIDERABLE attention is being directed to the application of electric welding in structural work. During recent years this method of joint-making has made rapid progress, due largely to economic reasons, because it is assumed that in those cases where it is adopted instead of riveting, weight and money are saved. This is undoubtedly a step forward, providing there is ample assurance that the jointing is satisfactory, will stand the test of time, and lends itself to rapid and effective repair, should damage necessitate such work.

The modern use of fusion joints instead of riveted or bolted connections has produced a variety of new forms which offer numerous fields of inquiry, covering a great range of problems. One set of problems relates to stress distribution, directed more especially to the determination of the maximum stresses in fusion joints. This is almost entirely an experimental matter, since nearly all such joints

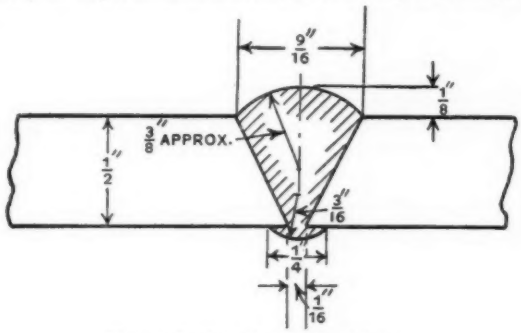


Fig. 1—Section of a fusion joint..

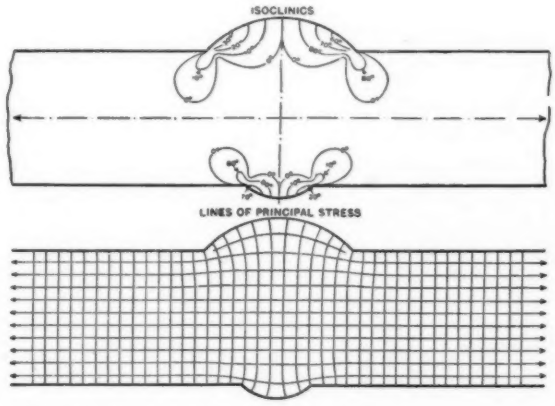


Fig. 2—Isoclinics and lines of principal stress.

have discontinuities imposed by practical necessities which render them insoluble by theoretical analysis, while little or no help can be gained from existing knowledge and long experience of riveted and bolted joints, on account of their essentially different nature. For these reasons a recent experimental investigation by Professor E. G. Coker, Miss R. Levi, and R. Russell is an important contribution to the subject. It deals with the subject of stress distribution in fusion joints, and has been used for measuring the stress at any point required by photo-elastic means.

The experiments have been carried out on loaded transparent models which could be viewed in polarised light, the application of which enables an observer to detect directions of stress at any point of a plane model stressed in its own plane, and by careful manipulation of the polariscope measurements may be obtained which render information respecting the stress at any point experimentally complete.

From a purely experimental point of view, the subject of stress distribution in fusion joints is of great interest, for nearly all the questions which arise are comparatively new and important. Because of this it is a matter of urgency to try and find approximate solutions of such as will yield to treatment. In the study of the subject by the investigators previously mentioned, some typical butt welds of an unsymmetrical type were, in the first instance, analysed experimentally. One form of butt joint used for plates of about ½ in. in thickness is formed by chamfering each plate from one side only, so that when they are brought together in line there is a single groove of triangular

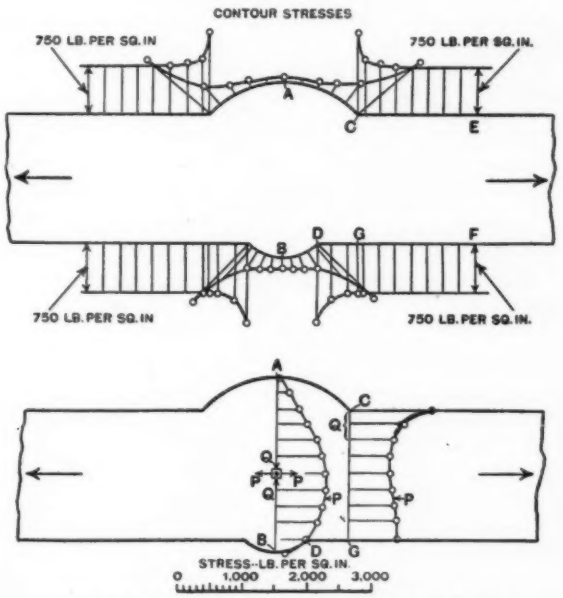


Fig. 3—Stress distributions for a load of 136 lbs.

section to be fitted in with fusion metal. The latter usually takes the form shown in Fig. 1.

When such a model is loaded by a central tensional pull in a field of circularly polarised light, all the junctions of the curved parts of the contour with the straight sides are seen to be places of maximum stress intensity, for the colour bands or isochromatics are observed to cluster there. These high stresses are to be expected because of the discontinuities. An explanation of this is shown when the directions of the principal stresses are traced across the joint by aid of direction bands or isoclinics, which are easily observed in plane polarised light, especially when the stress intensity is small. These isoclinics are shown in the upper part of Fig. 2, with the directions of stress marked on them, as observed in a polariscope, from which is drawn the lower diagram of the directions of the stresses throughout the joint and into each plate where they become parallel to the contours.

Stress intensities are readily measured by comparing the isochromatics at the edges with the colours observed in a simple tension member by matching in the usual manner, and, in this case, this has been carried out for a uniform tension stress of 750 lb. per sq. in. in the plates

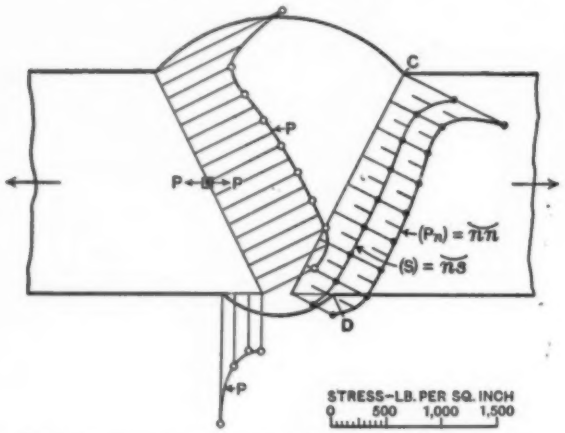


Fig. 4—Stresses on the junction planes for a load of 138 lbs.

to be joined. Where these measurements are plotted perpendicularly to the contours at the places where they are made, as in Fig. 3, the local increases of stress at the discontinuities die away very rapidly, but at the abrupt changes of section along the upper side they mount to an intensity of 1,200 lb. per sq. in., an increase of 71%, while at the ends of the seal weld the stress is 1,200 lb. per sq. in. The lower diagram of Fig. 3 shows the distribution found at the central cross-section A B, and it is noteworthy that the principal stress P is very small at and near the ends. The most important sections to consider, however, are the inclined junction planes, since the stress along these is of more vital importance. They prove to be of a simple character, for, as Figs. 2 and 3 indicate, the distribution is almost entirely a simple stress in a direction parallel, or nearly so, to the edges of the plate, and therefore inclined at an angle of about 63° to the section plane. There are, naturally, considerable variations of stress close to the ends of each junction plane, as the measured values of Fig. 4 show, but it is of interest to note that apart from these end variations the distribution is otherwise fairly uniform. Hence, both the normal stress $n\,n$ and the shear stress $n\,s$ must be of a very similar type, as the observations of Fig. 5 show.

Other ways of connecting plates in line are considered, in which a joint is made by a lenticular section of weld metal on one side and a cover plate on the other, the ends of the latter being joined to the main plates by triangular sections of fusion metal. When the gap between the two main plates is sufficient, the lenticular section of metal may be replaced by a pair of triangular fillets binding the inner ends of the plates to the cover strap, and this form is also dealt with. The effects of triangular fillets of lesser height than the butt straps and of corresponding fillets of curved quadrantal form are also examined with reference to a double butt strap joint. The paper, which gives a report of this investigation, concludes with a brief summary of the main results afforded by the experimental analysis.

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Direct Determination of Chromium and of Vanadium in Steel.

AT the present time the most accurate methods of determining the chromium contents of steel involve the direct titration of the chromic acid, obtained from a persulphate or similar oxidation, with standard ferrous sulphate. The end point may be determined either potentiometrically or with an oxidation-reduction indicator. If vanadium is present in the steel, as is very often the case, vanadic acid is formed in the oxidation process, and this substance is titrated along with the chromic acid. It is necessary, then, to determine vanadium before the percentage of chromium can be estimated.

The desirability of the direct determination of chromium and of vanadium in steels has led to the suggestion of a number of methods. A more recent method is that suggested by Hobart H. Willard and Philena Young,* who state that, after oxidising chromium and vanadium in a steel by the perchloric acid method and adding a measured excess of ferrous sulphate to reduce the chromic and vanadic acids, the excess may be titrated at room temperature with standard permanganate, using o-phenanthroline ferrous complex as an oxidation-reduction indicator. The reaction between permanganate and vanadyl ions in this solution of high acidity is sufficiently slow so that an excellent end point is obtained. If the hydrogen-ion concentration of this solution is reduced and the temperature raised somewhat, the vanadyl ion may then be titrated with standard permanganate because the indicator has such a high oxidation potential that it is not affected by the vanadic acid formed in this reaction. This gives a rapid indicator method of determining both chromium and vanadium in a single sample.

The same double titration may be used after oxidation of the chromium and vanadium in a steel by the permanganate-azide or persulphate-hydrochloric acid method. Neither of these methods is as rapid as the perchloric acid method.

Thallium.

THALLIUM derives its name from the characteristic green colour (thallus, the green twig) of one of its chief spectrum lines. Salts of thallium introduced into the path of the carbon arc produce an intense green flame. The element is relatively rare. It is a by-product obtained from certain cupriferous pyrites ores, the zinc ores of Leadville, Colorado, and the flue dust and chamber deposits of sulphuric-acid plants.

Thallium metal is soft and bluish white, resembling lead in appearance and in many of its properties. The metal is soluble in mineral acids, including sulphuric, in contradistinction in this respect to lead. The melting-point is 300° C., and the boiling point about 1,500° C.

Apart from its present chief use as a poison for rodents and ants, thallium has been an interesting metal for study for the electrochemist. The lead-thallium alloys are especially attractive. The fusion curve of these alloys belongs to the unusual small group of alloys whose melting points are higher than that of either constituent—in the case of most metals the binary alloys have a lower melting point than either constituent.

Third Blast-Furnace Completed at Kuznetsk.

THE third blast-furnace to be put into operation at the Kuznetsk Metallurgical Works is one of the largest in the world. The first two blast-furnaces in the Kuznetsk Combine have a heating area of 828 cu. m., with a capacity of 800 tons of cast iron per day, but the third additional furnace has a heating area of 1,180 cu. m., with a capacity of 1,200 tons of cast iron per day. All the processes are mechanised in this new furnace; the whole operation, including the transport of ore from the ore yards to the removal of the cast iron from the furnace, is performed by machinery.

* *Ind. and Eng. Chem.*, Anal. Ed., vol. 6, No. 1, pp. 48–?.

Business Notes and News

British Shipping Hope.

The end of the long controversy over the great Cunarder is now apparent, in view of the White Paper issued and the recent statement by Mr. Hore-Belisha in the House of Commons. The Cunard and White Star companies are amalgamated by the new arrangement into one great merger company which should be strong enough to restore the prestige of British shipping in the Atlantic. By this agreement, the Government enters the shipping world as an investor on a large scale, since it involves the advancement by the Government of £3,000,000 in three equal instalments. Another £1,500,000 is to be paid out in instalments for working capital to the merger company, and the Treasury is to ask for power to advance a further £5,000,000 for the building of a sister ship.

It is good news that there is to be no more delay, and work is to be resumed on the hull, now on the stocks, before the end of March in an effort to launch the vessel in the autumn. It is not yet decided where the second vessel is to be built, and the claims of the Tyne will not be overlooked, particularly as building could proceed with that of the vessel now partly constructed on the Clyde. The friendly rivalry that exists between the shipbuilders of the Clyde and the Tyne could be used with advantage, as in the case of the Lusitania and Mauritania. In any case, it is probable that the second Cunarder will be started at an early date.

New Railway Coaches.

The London Midland and Scottish Railway Company has placed contracts for 100 third-class vestibuled coaches, divided equally between the Birmingham Railway Carriage and Wagon Co., Ltd., of Smethwick, and the Metropolitan-Cammell Carriage Wagon and Finance Co., Ltd., of Saltley, and also for twenty vestibuled third-class brake coaches, which have been ordered from R. Y. Pickering and Co., Ltd., of Wishaw.

These 120 vehicles will be of the L.M.S. latest standard type, having steel underframes and steel-sheeted wooden bodies. It is understood that a further 200 third-class corridor coaches are to be put in hand by the London Midland and Scottish Railway at an early date at its works at Derby and Wolverton.

Malleable Iron Foundry Expansion.

Ley's Malleable Castings Co., Ltd., whose foundry is claimed to be the largest of its kind in Europe, have planned a further extension of about one-third of the existing foundry area. This involves the erection of an additional foundry for which the necessary plant is in process of preparation, and it is expected that the buildings will be ready for production in June. With this extension the area of the works will be increased to 40 acres, and will have a capacity of 400 tons of malleable castings per week.

The black-heart type of malleable castings is made by this firm, and it is claimed for this type that it is less sensitive to changes of section than are other types of malleable. At these works production is carried out on modern lines with the strictest control of the metal composition and manufacture, and it is claimed by the methods adopted a high tensile casting with a high yield-point and excellent ductility is achieved. Further, owing to the presence of graphitic temper carbon and the absence of hard spots, extremely high machining speeds are obtainable, with reduced wear and tear on tools. Another feature claimed for Ley's malleable iron is its high magnetic permeability and low hysteresis loss. The tensile strength is regular at 24 tons per sq. in., elongation 18%, and it has a cold bend test of 180°.

New Grade Quenching Oils.

An arrangement has been entered into between G.W.B. Electric Furnaces, Ltd., and Shell-Mex and B.P., Ltd., whereby new grade quenching oils will be marketed. These oils are being specially manufactured by Shell-Mex and B.P., Ltd., in close collaboration with Wild-Barfield Electric Furnaces, Ltd., full use of whose experience of hardening-shop requirements has been made.

These oils will be known as Shell-Wild-Barfield quenching oils, and information regarding them can be obtained on application to any of the branches of Shell-Mex and B.P., Ltd., or from G.W.B. Electric Furnaces, Ltd., London or Dudley.

Portable Solar Kitchen-stove.

Reports have recently appeared in the press regarding the utilisation of solar energy in Soviet Central Asia for domestic and industrial purposes. Baths are already in use, heated entirely by the sun's rays, and others are being installed in Tiflis and other places.

The Helio Institute of the U.S.S.R. has just constructed a kettle and solar kitchen-stove of a portable type. Any dinner can be cooked on this stove in two hours. The price of the stove, which is designed for twelve persons, is only 30 roubles.

The Helio Institute has recently carried out some important experiments in the use of the sun's rays in melting copper sulphate. Very simple equipment was used in which the temperature rapidly reached 120 degrees. Plans are now being made for the construction of a big sulphur melting plant which will work entirely on solar energy. The building of this plant will be commenced in 1935.

The Helio Institute has designed a special solar apparatus for turning sea water into fresh water. This is of great significance, as up to the present, barges are sent from Baku to take fresh water to Krasnovodsk, a town on the Caspian Sea.

Coke Ovens to be Restarted

The coke ovens and by-product plant of the Blaenavon Co., Ltd., which have been idle since the general strike of 1926, are to be restarted at an early date, and about 120 men will be taken on. Though no reference is made to the blast-furnaces, there is reason to believe, according to reports in circulation, that early developments now in contemplation may lead to the blast-furnaces being recommissioned.

Galloway's Boiler Section taken over by Daniel Adamson & Co., Ltd.

Arrangements have been made whereby Daniel Adamson & Co., Ltd., of Dukinfield, have taken over the goodwill, drawings, and patterns of the boiler section business of Messrs. Galloway's, Ltd., including the section of their business embodying mild steel riveted and welded tanks and other plating work. These arrangements are in addition to the goodwill, etc., which this firm has already acquired from Messrs. James Carmichael and Co., Ltd., of Dundee, and Messrs. Tinker's, Ltd., of Hyde.

The modern trend in design and practice in steam-raising plant is opening up new field for higher efficiency and consequent increased economies, and besides making themselves responsible for work formerly carried on by these firms, Messrs. Daniel Adamson & Co., Ltd., who are designers and manufacturers of all classes of shell boilers and steam turbine plant, are in close touch with all recent developments. This firm has been in successful operation over 80 years, during which time it has been associated with boiler and power-plant progress, and these arrangements will enhance facilities for service in this class of work.

Electric Furnace Developments.

The recent improvement in trade is shown by the number and variety of electric furnaces recently ordered from the Electric Furnace Co., Ltd., and its subsidiary company the Electric Resistance Furnace Co., Ltd.

Furnaces put to work or ordered since the beginning of 1934 include high-frequency installations in England, one of which is the largest yet installed in this country; a high-frequency plant including several furnaces, for use in a Belgian steel foundry; a high-frequency equipment for South Africa; a number of Ajax-Wyatt brass furnaces for use in this country and abroad; a large calcium carbide furnace for South Africa; hardening and tempering furnaces for a French motor-car manufacturer; and many furnaces for use in steel, brass, aluminium, glass, and cement works.

Catalogues and other Publications.

A very useful data book has been prepared and published by the Telegraph Construction and Maintenance Co., Ltd., giving very full information regarding "Telcon" electric resistance materials. The book is carefully designed to be of real assistance to manufacturers, designers, and others engaged in the manufacture of industrial and domestic electric-heating elements. The data relates to Pyromic 80–20 induction melted nickel-chromium wire, rod, and tape, and Calomic induction melted nickel-chromium-iron wire, rod and tape. Copies are available from Wild-Barfield Electric Furnaces Ltd., Elecfurn Works, North Road, London, N.7. who are the sole distributors of these special alloys.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£37 10 0 to £40	0	0
Chinese	26	15	0
Crude	20	0	0

BRASS.

Solid Drawn Tubes	lb.	9d.
Brazed Tubes	„	11d.
Rods Drawn	„	8⅝d.
Wire	„	7⅜d.
*Extruded Brass Bars	„	4½d.

COPPER.

Standard Cash	£32	8	0
Electrolytic	35	15	0
Best Selected	35	0	0
Tough	34	10	0
Sheets	64	0	0
Wire Bars	36	0	0
Ingot Bars	36	0	0
Solid Drawn Tubes	lb.	10d.	
Brazed Tubes	„	10d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	2	9
‡Ferro Tungsten	„	0	2	6
NOMINAL: Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up. 2–4% Carbon, scale 11/– per unit	ton	33	2	6
4–6% Carbon, scale 7/– per unit	„	23	0	0
6–8% Carbon, scale 7/– per unit	„	22	10	0
8–10% Carbon, scale 7/– per unit	„	22	10	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34	5	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	10	0
§Guar. max. 0·7% Carbon, scale 15/– per unit	„	39	2	6
‡Manganese Metal 97–98% Mn.	lb.	0	1	4
‡Metallic Chromium	„	0	2	5
§Ferro-Vanadium 25–50%	„	0	12	8
§Spiegel, 18–20%	ton	7	10	0
Ferro Silicon— Basis 10%, scale 3/– per unit	ton	5	2	6
20/30% basis 25%, scale 3/6 per unit	„	7	17	6
45/50% basis 45%, scale 5/– per unit	„	11	17	6
70/80% basis 75%, scale 7/– per unit	„	18	10	0
90/95% basis 90%, scale 10/– per unit	„	30	0	0
Silico Manganese 65/75% Mn., basis 65% Mn.	„	13	15	0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	15	18	0
§Ferro-Molybdenum, Molyte	lb.	0	5	6
§Calcium Molybdate	„	0	5	4

FUELS.

Foundry Coke—			
S. Wales	—	1	7	6
Scotland	—	1	8	0
Durham	1 1 0 to	1	5	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	0 17 6 to	0	18	6
Durham	—	0	18	0

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£52	0	0
*Commercial Ingots	40	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0	9
*Cored Bars	„	0	0	11

LEAD.

Soft Foreign	£11	9	0
English	13	0	0

MANUFACTURED IRON.

Scotland— Crown Bars, Best	£10	5	0
N.E. Coast— Rivets	10	15	0
Best Bars	10	5	0
Common Bars	9	5	0
Lancashire— Crown Bars	9	0	0
Hoops £10 10 0 to	12	0	0
Midlands— Crown Bars £8 0 0 to	9	0	0
Marked Bars	12	0	0
Unmarked Bars	—		
Nut and Bolt Bars £6 15 0 to	7	10	0
Gas Strip	10	12	6
S. Yorks — Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

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*Cored Bars	„	11d.
†Strip	„	10½d.
†Sheet to 10 W.G.	„	11d.
†Wire	„	11⅞d.
†Rods	„	11d.
†Tubes	„	1/4
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†Phos. Tin (5%) £30 above English Ingots.

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Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast— Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands— N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants— Foundry No. 1	3	10	6
Forge No. 4	3	3	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	7	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

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Billets Kr. 230-290 £12 13 4–£16 0 0
Wire Rods Kr. 265-320 £14 12 6–£17 12 6
Rolled Bars (dead soft) Kr. 185-210 £10 4 0–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton, f.o.b. Gothenburg.

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„ Braziery	26	0	0
„ Wire	—		
Brass	20	0	0
Gun Metal	26	0	0
Zinc	10	0	0
Aluminium Cuttings	68	0	0
Lead	11	0	0
Heavy Steel— S. Wales	2	16	6
Scotland	2	14	6
Cleveland	2	14	0
Cast Iron— Midlands	2	7	6
S. Wales	2	7	0
Cleveland	2	14	0
Steel Turnings— Cleveland	1	17	6
Midlands	1	13	6
Cast Iron Borings— Cleveland	1	10	0
Scotland	2	0	0

SPELTER.

G.O.B. Official	—		
Hard	£12	0	0
English	15	10	0
India	14	5	0
Re-melted	15	0	0

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	9	0	0
„ „ (Marine) „	—		
„ „ (Land), N.E. Coast	10	0	0
„ „ (Marine) „	10	10	0
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails £8 10 0 to	8	15	0
Sheffield— Siemens Acid Billets	9	2	6
Hard Basic £8 2 6 and	8	12	6
Medium Basic £6 12 6 and	7	2	6
Soft Basic	6	0	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	5	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/–
Finished Bars 18% Tungsten	„	2/9
Extras Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to $\frac{1}{16}$ in.	„	1/–
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅛ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/–

TIN.

Standard Cash	£225	10	0
English	226	0	0
Australian	—		
Eastern	—		
Tin Plates I.C. 20 × 14 box	0	16	6

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English Sheets	£25	0	0
Rods	29	0	0
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Boiler Plates	—		

* McKechnie Brothers, Ltd., quoted Feb. 13. † C. Clifford & Son, Ltd., quoted Feb. 13. ‡ Murex Limited, quoted Feb. 13.

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§ Prices quoted Feb. 13, ex warehouse.